CATTLE AND SHEEP IN NORTH THAILAND

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MPW RURAL DEVELOPMENT PTY. LTD.
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WEST PERTH
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RUMINANTS IN THE HIGHLANDS OF NORTHERN THAILAND.

AN AGROSOCIOLOGICAL STUDY.

by L. FALVEY.

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The information on which this book is based was gathered over the eight years that Dr. Falvey has been associated with Thailand. Much of the experience was gained when he was a Research Fellow of the University of Queensland and located at Chiang Mai University, Thailand.

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This book is published in response to requests from various colleagues, especially fellow animal scientists in Thailand. It has been prepared as part of the promotional activities of MPW Rural Development Pty. Ltd. in this field. MPW Rural Development Pty. Ltd. provides professional consultancy services in various fields and is particularly skilled in animal production in most continents of the world.

The book presents a summary of research and pilot development work concerning cattle and sheep in the northern Thai highlands. Much research was conducted as part of the Thai Australian Highland Agricultural Project, a project of the Australian Development Assistance Bureau, and this is discussed in the context of all research conducted in the region and its differences from other more closely researched regions of Asia.

The book presents work of various Thai and other animal scientists; in particular, I wish to acknowledge inputs from Choke Mikled, Prakob Hengmichae, Egachai Thanyalippitak and Theera Visitpanich. The results of this work are now being applied in initial stages of development projects in the highlands. The integrated nature of highland production systems necessitates an association of livestock development with other agricultural developments. It is hoped that this book will promote further interest in cattle development in the highlands.

J. Lindsay Falvey

SUMMARY

The information presented discusses experiences and research results in social and technical fields that are necessary to determine factors limiting the production of cattle in the highland regions of northern Thailand and to develop strategies for improving the productivity of cattle and developing the cattle industry. Information concerning the region, which is similar to large parts of Burma, China, Vietnam and Laos, is scarce and the need for agricultural development of the region provided the impetus for presenting this information.

Productivity of cattle is low in all cases as are low levels of managerial, technical and economic inputs. Stock owners are generally not interested in increasing productivity because cattle are not raised on a commercial basis. Differences in ownership patterns and attitudes toward stock between ethnic groups are related to the purposes for which cattle are kept including their use as sacrifices in religious ceremonies. The principal constraints to development of the industry are nutrition, disease, theft and predators.

The native pastures consumed by native cattle in the highlands are limiting in nitrogen or phosphorus and possibly other nutrients for more than half of the year. Low productivity is associated with the low digestibility of feed, low feed intakes and low sodium content of herbage. Invasion of natural <u>Imperata cylindrica</u> pastures by <u>Eupatorium adenophorum</u> is reducing the carrying capacity of the area and is attributed to a lower level of vigor of <u>Imperata</u> in the highlands than is common in warmer regions.

Native highland cattle can make high liveweight gains (343 to 535 g $head^{-1}$ day^{-1}) when fed concentrates. Supplementation with urea, sodium, phosphorus and sulphur in the dry or wet seasons and supplementation with cut improved pasture herbage produce similar responses in liveweight gain (30% over no supplementation) which are primarily related to increased sodium and feed intake.

The principal technical constraint to development of the highland cattle industry is the poor nutritional regime provided by traditional systems, particularly sodium and feed intake deficiencies. Other constraints can be overcome by implementation of existing knowledge which could be stimulated by the increased cattle productivity possible through improved nutrition. Cattle are better adapted than buffalo and sheep to the highlands and the need for an improved economic base in the area suggests the need for development of the cattle industry.

CHAPTER 1

Cattle in South East Asia

About 60% of the human population of the world lives in the areas between the latitudes of 30°N and 30°S where the productivity of livestock from this region is 16-33% of the corresponding figures for the cooler latitudes (McDowell, 1972). Livestock in the warm climates are the product of unconscious selection by man for their ability to produce modest yields from limited resources and the natural selection of survivors of poor feed supplies and constant attack by diseases and parasites.

Populations of cattle and buffalo in South East Asia rose slightly during the period of 1971-73 and in 1973 were estimated to be 25,689,000 and 19,542,000 respectively (Madamba, 1976). In recent years, however, populations have probably been declining (Chantalakhana, 1978a). In the Philippines, ranching and grazing under plantation crops as well as backyard production contrast with sideline occupations in cattle raising for the production of draught animals in Thailand. In 1973, an estimated 8.9% of the total animal population of cattle and buffalo were slaughtered in the South East Asian regions, which provides an average of 2.2 kg of meat per person per year (Madamba, 1976). Consumption figures for Thailand are unreliable due to inaccurate estimates of the number of animals slaughtered, imported to and exported from Thailand.

Productivity of cattle in South East Asia has been reviewed by Chantalakhana (1978a) who presents yearling liveweights of 120.5, 117.0 and 150.5 - 173.1 kg for Thai, Bali and Korean cattle respectively. He estimates that the indigenous cattle in most South East Asian countries can grow at the rate of 0.20 - 0.35 kg head^{-1} day^{-1} to weaning. Crossbreeding produces higher liveweight gains when nutritious diets are fed. Sastradipraja and Sutardi (1977) have noted that the indigenous cattle are well adapted to the traditional agricultural areas in terms of utilization of poor quality roughages, tolerance to parasites and heat. They also note that there is a distinct lack of definitive information about these indigenous breeds.

The problems of the South East Asian cattle industries are poor management, poor quality stock, inefficient marketing and slow adoption of known improved techniques (Madamba, 1976). In Thailand however, Goff (1960) believes that veterinary inputs are the first requirement and Rumich (1966) supports this in the context of the interaction of problems of nutrition.

Programmes for genetic improvement have been advocated for the developing countries in general (McDowell, 1972) and Thailand in particular (Chantalakhana, 1978b). The basic assumption underlying such recommendations is that the genetic potential of the indigenous breeds is too low to warrant commercial inputs when adequate levels of nutrition are provided (McDowell, 1972). This essentially indicates that the first requirement is for diets of higher nutritional quality with some definition of the ability of native cattle to respond to improved nutrition.

A programme in the Angole district of India aimed to overcome the problem of low productivity associated with overstocking by planting of kikuyu grass (<u>Pennisetum</u> <u>clandestinum</u>), mass castration of inferior bulls and the training of veterinary assistants (Dunkel, 1978). Success in this project was attributed to the simultaneous improvements in nutrition and animal health rather than the tackling of these aspects separately. In regions where disease control knowledge exists, the first requirement may be for improved nutrition. The overriding technical limitation in Thailand is nutrition, particularly when animals are required to provide power as well as to survive and reproduce (Rumich, 1966). Means of overcoming the nutritional constraints of the region are probably required before the benefits of veterinary and genetic improvement inputs can be fully realized.

CHAPTER 2

Cattle and Buffalo in Thailand

INTRODUCTION

Thailand covers an area of 514,000 square kilometres and supports a human population of around 45 million. The country is divided into 72 administrative units called Changwats and agriculturally and ethnically can be divided into four zones, namely; the southern zone, the central zone, the north-east zone and the northern zone. Climatic differences and availability of irrigation lead to differences in agricultural practices and productivity between these regions. The northern zone produces rice in the lowland regions, in common with the other zones of Thailand, and the mountainous regions produce opium as the principal cash crop.

Livestock output of Thailand is second in value to that of crops with populations of cattle and buffalo of around 4.6 to 5.7 million respectively. These industries showed little change in production over the previous decade (anon, 1978) although Van der Meer (1978) notes that some changing economic patterns within villages have resulted from investment and trading in large ruminants. The national Economic and Social Development Plan of the Royal Thai Government commits the country to a policy of increasing cattle numbers and productivity (Anon, 1973). Ranching is implicitly promoted by regulations that require companies involved in cattle trading to also be involved in animal production; nevertheless, the majority of cattle are raised by smallholders (Rufener, 1971).

The origin of the cattle of Thailand has been studied and some observations (Anon, 1968a; Rife, 1960) indicate a separate development from the Indian Zebu. Payne (1970) and Epstein (1969) postulate that migration of cattle with people from southern China where cattle, sheep and goats can be traced to the neolithic period, to the areas now known as Burma, Thailand, Vietnam and Laos, and crossbreeding with the Zebu cattle migrating from the Indian penninsula, produced a range of cattle types that, with subsequent interbreeding

led to a breed that is fairly uniform. The cattle are medium sized (mean adult liveweights of 250-350 kg), short-horned, thoracic humped and usually light brown in colour, and their principal role is in draught. The introduction of a variety of Bos taurus and indicus breeds during this century led to crossbreeding with the native cattle in some regions of Thailand. Poorer or more isolated regions of Thailand, such as the mountainous north, have not shared in this infusion of exotic blood to any extent.

The proportion of cattle and buffalo in the various zones of Thailand in 1968 are presented in the following table. The average rates of increase in numbers of cattle and buffalo during the period 1961-72 were 0.84% and 1.95% respectively (Eusebio and Chantalakhana, 1978). Accuracy of such information, particularly in terms of the numbers of animals slaughtered per year, is often suspect due to large but undetermined numbers of illegal slaughterings.

Most farmers in central Thailand raise less than ten cattle, mainly males. Sales are infrequent, veterinary care seldom sought and calving usually occurs during the period of December to February (Prucarsi, 1976).

The percentage distribution of buffalo and cattle populations in the four zones of Thailand (1968-72).

Year	ZONE							
	North		North East		Central		South	
	Cattle	Buffalo	Cattle	Buffalo	Cattle	Buffalo	Cattle	Buffalo
1968	12.1	10.8	40.0	54.4	31.9	30.2	16.0	4.5
1969	12.2	11.1	40.5	55.2	32.0	29.5	15.3	4.2
1970	12.3	11.4	40.4	55.7	33.3	28.8	14.1	4.1
1971	12.3	11.4	40.4	55.7	33.7	28.8	14.1	4.1
1972	12.4	11.1	40.3	55.7	32.6	28.7	14.8	4.4

Grazing around the village and feeding of rice straw from the previous crop is common during the rice growing season and, animal management is largely oriented around the production of agricultural crops (Niumsup et al., 1978). Tractors are replacing buffalo and cattle in the more affluent provinces by allowing the cultivation of an additional crop per year.

The productivity of cattle in these regions of Thailand has been studied and reviewed by Chantalakhana et al.(1978a, 1978b). Birth weights range from a mean of 15.3 kg for indigenous cattle to 19.8 kg for ½ American Brahman x ½ indigenous cattle and higher for higher infusions of exotic blood. Average daily liveweight gains to weaning range from

269 g to 451 g for the same breeds. It should be noted however, that most cattle in such investigations are offered a supplementary feed not usually fed in villages.

Development and research concerned with livestock in Thailand is conducted by the Department of Livestock Development, Kasetsart University, the military, large commercial producers of pigs and chickens, and more recently, the provincial universities. Rufener (1971) noted that the two divisions of the Department of Livestock Development, Veterinary Science and Animal Husbandry, received the bulk of the Department's budget with the remainder being split between Animal Nutrition Research and Training. Recent analyses of the activities of the Department suggest an increased commitment to nutrition and extension. Assistance with increasing the effectiveness of the Department is to be provided by the World Bank and the Australian Development Assistance Bureau in 1984.

Research in the field of cattle nutrition has been conducted on experimental stations of the Department of Livestock Development usually to compare different breeds and crossbreeds produced from cattle breeding programmes. In many cases, the levels of nutrition available to the cattle in these experiments were in excess of those available to cattle in villages (see for example, Pinkerton, 1970). Under such experimental conditions crossbred animals were superior.

The utilization of by-products and supplements such as rice straw supplemented with urea (Malayabas, 1975), sugarcane bagasse (Kitiwan, 1976), water hyacinth (Plungsungkhet, 1977), silage (Chutina, 1973; Sripromma, 1977) and pineapple bran (Tanpipat, 1976) have been studied but there is no widespread use of any of these techniques. It would seem that, despite the policy of crossbreeding with introduced breeds of cattle which has been remarkably successful in north-east Thailand (Anon, 1968b), nutrition remains an outstanding constraint to development (Southcombe, 1979).

Animal health research has determined that internal parasites may reduce productivity (Wongsongsarn _et al_., 1967) and the control of serious diseases is practised in many regions of Thailand. It seems likely that disease need not be a constraint to development of bovine industries in Thailand today.

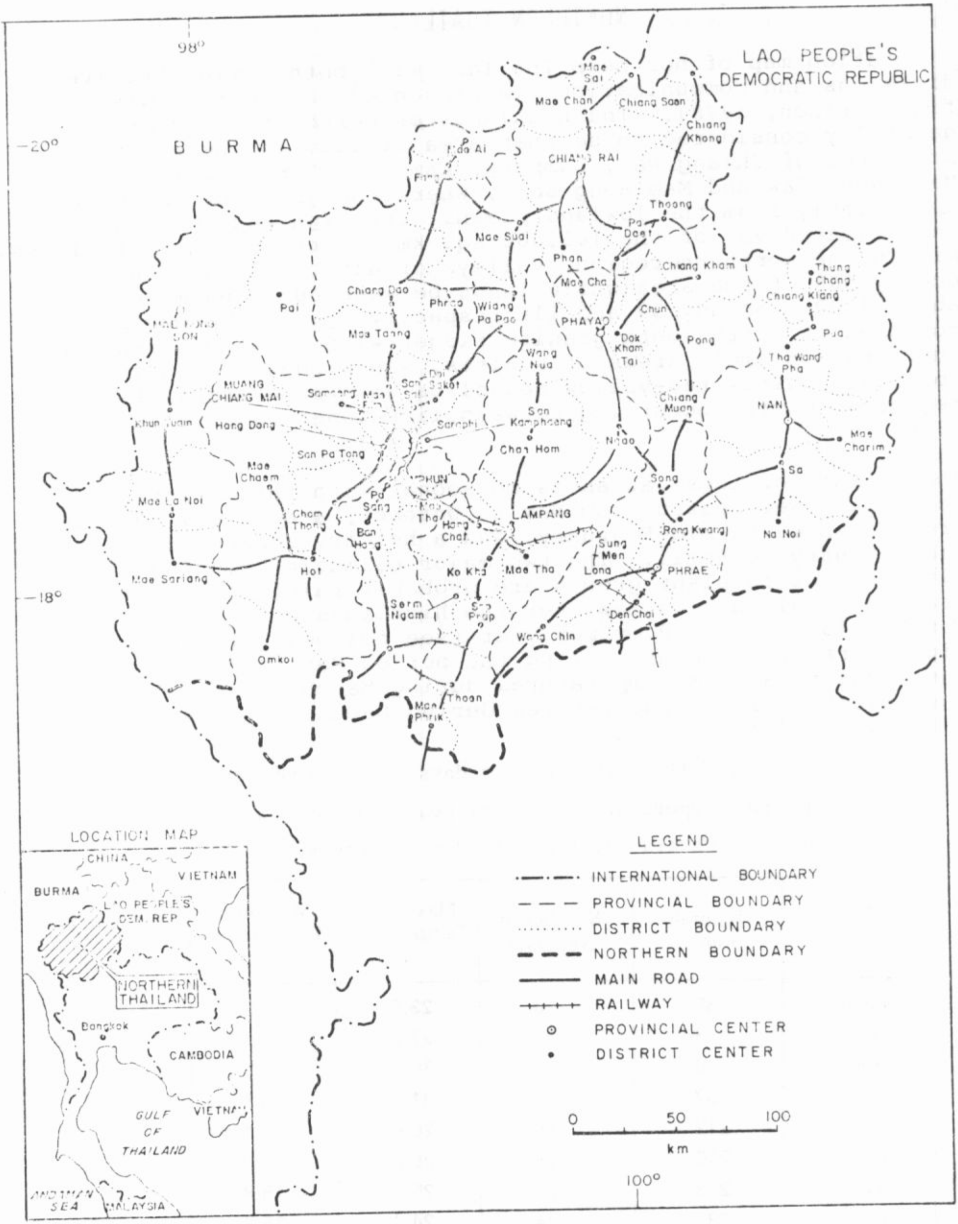
NORTHERN THAILAND

A location map of northern Thailand with both administrative divisions and communications is presented in the following figure (Anon, 1978). The highlands of north Thailand are generally considered to be that area of land in the eight provinces of Chiang Rai, Lampang, Lamphun, Phrae, Chiang Mai, Nan, Tak and Mae Hong Sorn, where the gradient varies appreciably from the lowland plain. The highlands comprise an estimated 75% of the 105,000 sq. km. in these eight provinces. Within the northern region, valleys of altitudes 250-600 m occupy 50% of the area while lands between 600-1200 m and above 1200 m occupy 39 and 11% respectively. The area is composed of north-south granite ridges with areas of limestone outcrops and small areas of schists, sandstones and shales. Soils are mainly red-yellow podzolics with some areas of red brown earths occurring between limestone crags (Gibson, 1976).

The climate of these areas is monsoonal with three distinct seasons; a wet season from May to October, a cool dry season from November to mid-February, and a hot dry season from mid-February to April. The two major climatic components with respect to plant growth are probably rainfall and temperature. Rainfall varies over the highlands but is usually between 1500 and 2200 mm per year (see following figure). Highest rainfall occurs during the period May to October, the highest maximum temperatures during March to April and the lowest minimum temperatures during December to January (Andrews, 1979).

Mean rainfall, number of wet days and maximum and minimum temperatures from six years data (1973 to 1978) at Pa Kia (altitude 1500 m) (Andrews, 1979).

Month	Rainfall (mm)	Number of Wet Days	Maximum Temperature (°C)	Minimum Temperature (°C)
January	38	3	23.5	10.3
February	3	1	27.8	12.5
March	9	1	30.9	15.3
April	57	7	31.0	16.8
May	212	18	26.6	16.4
June	215	18	25.2	16.0
July	233	23	25.0	15.8
August	297	24	24.4	15.7
September	308	22	24.9	15.6
October	174	14	23.9	14.9
November	48	8	22.1	12.8
December	18	2	20.8	10.8
Year	1612	141	25.5	14.4



Map of administrative divisions and communications

The vegetational cover over this 89,484 square kilometer region in 1961 was mainly dry dipterocarp forest (35%), mixed deciduous forest (27%) and swidden cultivation (19%) (R.F.D., 1973). From that time the predominance of forest, particularly of the dry dipterocarp type has decreased, by approximately 0.5 - 0.8% per year (Anon, 1978). Simultaneously with this decrease in forest cover there has been a reported increase in sediment of up to 175% over the period of 1950-1970 in the four main rivers draining the north of Thailand: the Ping, the Wang, the Yom and the Nan Rivers (Anon, 1978). For these reasons, a national policy to reafforest many areas of the highlands has been implemented and this has accelerated the need for changes in the traditional agricultural systems.

Shifting cultivation, as practised in the highlands, is also practised over large areas of the tropics to an estimated total of 36 million square kilometres and is a means of subsistence for more than 200 million people (Moody, 1975). South East Asia is the most densely populated tropical area yet about 7% of its farm land is under shifting cultivation. Population density in these regions averages ten persons per square kilometre compared with 68 for the paddy rice areas (Wongsprasert, 1974).

In the mountains of northern Thailand, swiddens are cut under three different systems. The first, a forest fallow, is one in which virgin or mature secondary forest is felled early in the year and the plot double-cropped to maize and opium for as many years as possible. The second, a subsistence based bush fallow, employs a one year cultivation and ten or less years forest regrowth. The third system is opportunistic supplementary shifting cultivation, which is practised by lowland people forced to clear swiddens in the highlands and does not involve planned rotational fallowing or control of fires (Gibson, 1976). The original forest cover rarely re-establishes after cutting except in the Karen system because fallow periods are short and savannah tends to dominate abandoned swiddens which leads to the dominance of Imperata cylindrica.

Imperata, which forms the basis of the small highland grazing industries, has been estimated to cover a total area of 2500 square kilometres in this region (Gibson and Van Diepen, 1977). Swiddens are only cut into these areas of Imperata if alternative land is unavailable; their only value is as pasture for the ruminants owned by the people in the region and, to a certain extent as roofing material for housing. Within the context of the cattle industry of the northern highlands, these Imperata cylindrica pastures are usually referred to as native or natural pastures.

Sociological background

It has been estimated that approximately 90% of the population of north Thailand is located in the lowlands (Anon, 1978). The highlands are occupied today by "hilltribes" who have

migrated from Burma and China over the past eighty years. Prior to this, sparse occupation of the area is postulated from the occasional discoveries of Buddist ruins (Penth, 1977).

The term, "hilltribes" includes the ethnic groups: Karen, Meo, Lahu, Yao, Lisu, Akha, Lua, Htin and Khama. Keen (1972) has noted that the highlands are also becoming more densely populated by Khon Muang, the ethnic Thais of lowland northern Thailand, who are forced out of the lowland regions by overcrowding and associated factors. The population of the highlands is constantly being further increased by immigration of hilltribe groups from bordering countries.

The total population of hilltribes is estimated to be approximately 400,000 (Tribal Research Centre information). Other ethnic groups present in the highlands are not included in these figures are the Kwo Min Tung (Chinese Nationalist forces) and the Yunnanese Haw, who together made up an estimated population of 15,000 in 1976 (Suwanbubpa, 1976).

The whole area of the highlands of north Thailand is classified as forest reserve which theoretically outlaws tree felling, burning and cultivation. Residents of the highlands employ their own systems of tenure, which although not recognized by the law, are strictly adhered to within the community. One dominant feature of land holding, despite variations in customs between and within tribes, is the right of any one family to cultivate all the unoccupied land that they are capable of using for as long a period as they desire. Sometimes the abandoned swiddens are used only by people from the same village of the same ethnic group but in other instances the swiddens of different ethnic groups merge in the same general area (Keen, 1972).

Villages have traditionally been moved frequently as the soil becomes exhausted in one vicinity. However, the vacant unused tracts of usable land that once were easily found, no longer exist. The problem of land shortage is beginning to be recognized by the highland residents but there is at present little overall evidence of changes in agricultural systems or in attitudes toward land. Karen people, who usually settle in the lower altitudes of the highlands have evolved a rotational system that permits them to stay in the one area and are therefore an exception while their population can be supported by that system.

Opium (Papaver somniferum) is the principal economic crop of the highlands and is grown on the less acidic friable soils above 1000 metres altitude by the Meo, Yao, Lahu, Lisu and Akha ethnic groups. Opium is usually grown in the cool season after a wet season corn crop. Opium producers and other highland residents plant upland rice which is consumed as a staple feed although yields are not usually sufficient for year round consumption and lowland rice must often be bought with money earned from the sale of opium.

Wet rice is grown in the valley bottoms mainly by Karen and Khon Muang people (Oughton and Imong, 1970).

After opium, miang tea is the next most important economic crop, occupying large forest areas in some watersheds. Indigenous tea (Camellia sinensis) trees are harvested for leaves and miang, the product of a lactic acid fermentation, is sold for chewing as a mild stimulant (Anon, 1978). Miang producers do not usually grow rice. Demand for miang is decreasing and alternative agricultural enterprises are being sought.

Other economic enterprises of the highlands are potatoes, native peaches and livestock. Substitute crops for opium are being promoted including red kidney beans and coffee.

Large Ruminant Industries in the Northern Highlands

Knowledge of the industry has been largely restriced to general definitions of the environment and the cattle. Various authors (Jones, 1967; Binney, 1968; Geddes, 1970; Wongsprasert, 1974; Hinton, 1975; Grandstaff, 1976) have mentioned livestock in their social studies although biological and economic dynamics have only been generated since 1976 from the Thai Australian Highland Agricultural Project.

The annual wildfires that escape during the preparation of new swiddens are regarded by about half of the highlanders as disastrous to their practised fallow system while the other half are more careless and may promote fires in order to facilitate hunting (Van der Meer, 1978). Imperata cylindrica arising from these annual wildfires represents the major pasture species for cattle in most areas of the highlands.

Cattle have probably been raised in the highlands since the present occupants of the region immigrated. Payne (1970) has defined the general breed to be of medium size, hardy and relatively long legged. This description however does not apply to the highland cattle which, although originally from the same genetic pool as those of the lowlands, probably have undergone different selection pressures and inbreeding in some areas. The cattle possess short ears that do not droop, exhibit strong sexual dimorphism, have a chromosome number of $2n = 60$ and exhibit acrocentricity of the Y chromosome. It has been noted for some time that there is great potential for increased production of income from livestock and that this relies largely on improved access to introduce disease control measures that are becomming common in other areas of Thailand (Anon, 1978).

Data from a survey of large areas of the highlands indicated cattle and buffalo populations to be approximately 4,000 head (Anon, 1978). Another estimate places figures at 60,000 and 46,200 respectively (Ashfaq and Kitiwan, 1976). Such disparities in estimates indicate the lack of active interest

in and knowledge of the industries in the highlands. Surveys reported by McKinnon (1977), Hinton (1975), Keen (1972) and Walker (1970) provide indications of the ownership of livestock within particular villages and some information concerning the attitudes of the people to their livestock.

Haemorhagic septicaemia and foot and mouth are diseases of importance while other possibilities include black leg, brucellosis, vibriosis, liver fluke and intestinal roundworms (Coates, 1974). Foot and mouth disease and haemorhagic septicaemia are the diseases most commonly considered to be of economic importance by district veterinarians and vaccines produced in country are available for use throughout Thailand including the highlands although they are not used universally.

Estimates of the grazing areas available per beast in hectares vary from 7 (Snook, 1975) to 25 (Ashfaq, 1975) and herding, if practised, is often carried out by children. Nutrition of cattle is assumed by the hilltribes to be adequate although this view is not shared by researchers (Gibson, 1976) and the possibility of mineral deficiencies has been suggested by Snook (1975). Agronomic research into means of improving nutrition through the introduction of legume pastures began in 1972 but is not practised by the highland residents (Gibson, 1976).

DEVELOPMENT OF LIVESTOCK IN THE HIGHLANDS

The two overriding political reasons for agricultural development work in this region are; to provide alternatives to opium production, and to control sensitive border regions occupied by non Thai ethnic groups. In sociological and agricultural terms the problems are seen to be poor diets (Piriyamaskul, 1978) and unsuitable cultivation techniques. The principle aim of hilltribe people is to grow sufficient rice for each year. Opium is a cash crop that enables hilltribe people to purchase rice for that period of the year for which their own production is inadequate. Opium is usually grown if land availability is low because the returns to labour are higher for rice than for opium production (Van der Meer, 1978). Environmental damage caused by shifting cultivation as recorded in siltation of lowland irrigation systems and the supposed increased water runoff from grassland have commonly been used as reasons for changed land use in this region. McKinnon (1977) has noted that shifting cultivation is an ecologically and economically sound system, under conditions of unlimited land. Increased land pressure has today resulted in a general decrease in soil fertility as fallow periods are shortened. A potential solution to this problem, which incidentally could lead to decreased production of opium, is the seeking of alternative cash crops of which coffee is probably the most promising (Keo-Ngarm, 1977). Another rationale is to improve the subsistence base of the people through seeking means for increasing rice production to cover the requirements of the whole year

(TAHAP, 1978). Assuming that people will usually seek an alternative that minimizes labour inputs, production of opium would not be favoured by farmers if alternatives were available from either of the above approaches to development.

CHAPTER 3

Nutrition and Imperata

GENERAL NUTRITION

Livestock grazing on unimproved pastures and crop residues commonly do not receive a diet of high nutritional quality. The most widespread deficiency in the tropical regions is of nitrogen or protein. The efficiency of microbial protein production in the rumen is dependant on a threshold level of nitrogen in the ingesta of the order of 2.0 - 2.8 g available nitrogen per 100 g of organic matter digested in the rumen (McMeniman and Armstrong, 1977). Deficiency of nitrogen in the diet is probably the most difficult single deficiency to overcome in most tropical regions.

Phosphorus is probably the next most commonly recorded deficient nutrient (Cohen, 1975). Numerous other mineral deficiencies, imbalances and toxicities are severely limiting the cattle industries of most developing countries. Deficiencies of: calcium, magnesium, phosphorus, potassium, sodium, sulphur, cobalt, copper, molybdenum induced copper, iodine, iron, manganese, selenium, zinc and toxicities of fluorine, manganese and selenium have been recorded in 10, 12, 35, 4, 12, 2, 19, 17, worldwide 2, 7, 4, 6, 10, 2 and 18 developing countries respectively (McDowell, 1976). Most of these naturally occurring deficiencies are associated with specific soil characteristics with some interactions between the soil and the plant species and the maturity of forage on offer in addition to the biological status of the stock in question. Predictions of probable deficiencies and toxicities in cattle from chemical analysis of the diet, plasma, whole blood, serum, saliva, urine, liver, milk, bone or hair are possible and McDowell (1976) has published critical levels for 18 essential minerals using these analysis.

Such techniques, in common with the correlation of "deficiency symptoms" to specific nutrient deficiencies provide a useful indication of the nutritional status of livestock. However, controlled experimentation is usually necessary to define a particular deficiency and to assess its economic importance.

General productivity on a herd basis may not provide that information because one cannot partition responses to different nutrients. The high priority on demand of maternal reserves exercised by the foetus precludes any recognition of a mild deficiency in terms of the number of calves stillborn, although birth weights may provide a more reliable indication (N.A.S., 1968).

Improved pastures are uncommon in South East Asia, tropical Australia, and New Guinea, and those ruminants not fed on crop residues exist mainly on native pastures. In tropical Australia, Norman (1965) has noted that native pasture is most efficiently used after the first rains of the wet season when its nutrient content may be higher than that of improved pastures. Throughout the remainder of the year however, native pastures are regarded at best, as a reasonable source of energy that can be utilized in conjunction with supplementation as a maintenance diet (Speck, 1965; Norman and Begg, 1973).

The seasonal liveweight changes of cattle grazing native pastures in northern Australia has been related to their nitrogen intake (Falvey, 1979a). Liveweight gains in steers have been estimated to cease when the nitrogen content of the whole plant falls below 11.0 g kg DM^{-1} (Milford, 1960), provided no other nutrient is already limiting. Thus even at stocking rates low enough to allow selective grazing, the diet may still be too low in nitrogen content to maintain liveweight (Norman, 1965). The relative proportions of by-pass protein may vary requirements slightly.

Comparisons between the productivity of similar native pastures in different environments (for example; Norman, 1965 and Wesley-Smith, 1972) suggest that the rate of decline in digestibility may be a factor of major importance. In the humid dry tropics, such variation between environments may be caused by differences in dews, humidity, temperature and rainfall pattern.

Nutrient deficiencies for plant growth can provide some indication of possible deficiencies that may occur in ruminants grazing these plants. Research to determine the specific nutrients deficient for plant growth in the Thai highlands has been conducted by Gibson (1977) and Sampet (1978); deficiencies of nitrogen, phosphorus, sulphur, zinc, boron, manganese, molybdenum, potassium and calcium have been recorded for various highland soils. The most widespread soil type is granite derived and is deficient in nitrogen, phosphorus, sulphur and zinc. Calcium levels in the soil are also marginal.

The predominant native pasture species present on the granite soils in the highlands is the grass <u>Imperata cylindrica</u> (L.) Beauv, which populates abandoned swiddens and dominates large areas of the highland landscape where annual wildfires occur.

IMPERATA CYLINDRICA (L.) BEAUV

The total area of Imperata grasslands in the world has been estimated at 500 million hectares, about 200 million of which is in South East Asia (Martoatomodjo, 1976). In Indonesia, some 16 million hectares increasing at the rate of 1.25% per annum, are dominated by Imperata while another 23 million hectares increasing at the rate of 1.05% per annum, support shrubs that may have once been associated with an Imperata dominant sward (Soerjani, 1976). In Malaysia there is an estimated 1.6 million hectares of Imperata which is largely restricted to the understory of rubber plantations (Ivens, 1975).

Imperata is known by various names throughout the world, for example; "lalang" in Malaysia, "cogon" in the Philippines, "illuk" in Sri Lanka, "Cotranh" in Vietnam, "sbauv" in Kampuchea, "yakha" in Laos and Thailand, and "alang-alang" in Indonesia. The principal variety of Imperata cylindrica is found in Asia, Australia, India and East Tropical Africa. Other varieties are africana found in Africa, europea found in the Mediterranean region, Central Asia and the Central Sahara, condensata found in Chili and latifolia found in India (Eussen, 1976). The variety common to South East Asia is a more aggressively rhizomatous plant than the africana variety.

Ecology

The association between Imperata dominance and the frequency of burning is attested to by more than 60 references summarized by Bartlett (1957). Before the action of man, mainly through slash and burn agriculture, Imperata was probably restricted to the sterile acid tracts of land in the tropics (Eussen, 1976).

While Imperata often occurs as a near-pure sward, it is associated with other species in some areas such as in the Lesser Sunda Islands where the other species are Andropogon spp., Saccharum spontaneum and Themeda arundinaces. In Java the associated species are Panicum repens and Saccharum spontaneum or Eupatorium odoratum, E. inulifolium, Digitaria adsendens and Paspalum conjugatum (Eussen, 1976). Successions to Imperata are possibly affected by grazing and may therefore be comprised of species that are tolerant to grazing or unpalatable.

In West Africa the associated species are Pennisetum species and Panicum maximum (Ivens, 1976). The degree of association is apparently increased by exclusion from fire and the plant species involved are usually those with deeper root systems (Eussen, 1976) which enables them to compete more effectively with, and to eventually overtop Imperata (Ivens, 1976).

Succession from Imperata to secondary forest is postulated to begin with these associations with other species promoted by the absence of fire (Ivens, 1976) and cutting (Sajise, 1973). Thereafter, in the Indonesian situation, an Imperata, Solanum species, Nephrolephasis species with Paspalum and Ageratum association becomes established which is gradually

replaced by a Ficus species, Macarunga species, Solanum species and Histiopheris species association. The formation of an above ground canopy then shades the Imperata which reduces its vigor and persistance (Eussen, 1976).

Agronomy

Imperata is fire resistant, due to persistent underground rhizomes, and has a high regenerative capacity. It is adaptable to infertile soils but is intolerant of frequent defoliation, heavy shading and continuous waterlogging (Coster, 1931, quoted in Soeriangegara, 1976).

The seeds of Imperata are easily airborne due to their plumose structure and can adhere to rough or wet surfaces (Santiago, 1976). Germination increases from 9% at 20°C to a maximum of approximately 55% at 30°C and viability of seed declines only slightly during storage (Dickens and Moore, 1974).

Once established, the persistence of Imperata is related primarily to its ability to evade the effect of fire and infrequent cutting or grazing. These are a function of the sympodial rhizomes which contain meristematic buds of shoots, leaves and inflorescences below the soil surface. Fires may actually increase the density of Imperata by killing other species and activating the axillary buds of the sympodial branches to produce leaf shoots and flowers (Santiago, 1976). More than 80% of shoots originate from rhizomes less than 15 cm below the soil surface (Ivens, 1975).

Flowering normally occurs during the hot season (Eussen, 1976) as a result of water stress (Santiago, 1976) but may be induced by burning or cutting at any time although few of the seed heads so stimulated actually produce seeds (Eussen, 1976). Flowering in this situation is of far less importance than the rhizome system in terms of survival. Santiago (1976) has recorded successful establishment of Imperata from several rhizomes containing only two nodes, thereby indicating the ability of the species to survive not only fire but also mechanical damage. Individual rhizome branches have a limited life, however the action of perenniating is through continuous production of new rhizome branches from clonal shoots.

The association of Imperata with acid soils has been suggested to be actually caused by the grass (Sajise, 1976). It has been postulated that sugars exuded from rhizomes of Imperata are acted upon by microorganisms that convert the sugars to organic acids which may then cause an acid soil reaction. On the other hand, the regular burning of Imperata swards may increase soil pH through the addition of bases to the soil (Soepardi, 1976).

Economic Importance

Imperata is most commonly recognized as a weed rather than a useful species. For this reason, the main emphasis of research conducted with *Imperata* has been concerned with its control or eradication. *Imperata* is regarded as the weed species of greatest importance in forest lands in South East Asia (Soeriangegara, 1976) and in Indonesia *Imperata* dominated areas are designated as degraded areas (Soerjani, 1976).

Control of *Imperata* can be effected by chemicals such as dalapon (Soedarsan, 1976) and mechanical methods based on deep cultivation during the dry season followed by repeated cutting (Ivens, 1976) or even apparently by biological means such as the gallmidge *Orseoliella javenica* (Mangoendihardjo, 1976). Natural biological control by shading from regenerating forest while effective, may not be compatible with land use strategies in areas of high population pressure.

Utilization of *Imperata* has probably been practised for centuries in such forms as thatching, traps for large animals and grazing (Wongsprasert, 1974). In Bali *Imperata* is primarily managed for thatching purposes; after cutting of mature growth, the regrowth is grazed by cattle for a period until the area is again shut up for production of thatching material. Utilization of *Imperata* by grazing is probably the most common of these and while usually recognized as a poor quality pasture, plantings on a restricted basis in North America have been recorded and in 1949 the area covered by *Imperata* was estimated at about 450 hectares (Tabor, 1949).

Early research (Heyne, 1927; Pepa, 1927; Chevalier, 1933; Georgi, 1934; Bunting and March, 1934; Patton, 1941; Hubbard *et al.*, 1944) studied *Imperata* as a forage species and noted its nutritive value, suitability for silage production, dry matter production and association with other crops. Nevertheless, the cursory nature of these studies does not enable any statement to be made about the role, both present and potential of *Imperata* in animal production.

A more common view today is that *Imperata* is a natural resource that can be utilized profitably in some situations (Holmes *et al.*, 1976) while in others partial replacement with other pasture species is recommended (Gibson, 1976).

Animal production

The nutritive value of *Imperata* in Malaysia and its use in feed mixes have been recorded (Hutagalung, 1977). The variability of nutritive value according to site and maturity is ignored in this approach which assumes a constant quality and there is little doubt that for most of the year, the crude protein content of *Imperata* is below the level of 11.7% presented in the above study. Other studies although more detailed also ignore the variations that must occur with maturity.

Well designed concise studies on the nutritive value and animal production potential of *Imperata* are scarce, the principle ones being those of Holmes *et al*. (1976), Soewardi and Sastradipradja (1976), Soewardi *et al*. (1975; 1976) and Magadan *et al*. (1974).

Imperata in Papua New Guinea subjected to four weekly cutting depresses production to the extent that although nitrogen content is high, dry matter production is below that of introduced grasses.

If the general figure of 11.0 g kg^{-1} nitrogen in dry matter is accepted as the critical level below which liveweight gain cannot be expected in steers and non-lactating cows (Milford, 1960; Milford and Haydock, 1965), then the Papua New Guinea data suggest that *Imperata* is only providing an adequate diet up to six weeks of age. Similar conclusions for *Imperata* in Indonesia have been reached (Soewardi and Sastrapipradja, 1976).

The digestibility of *Imperata* is probably the most critical of the parameters of nutritive value. *Imperata* shows lower relative digestibilities that *Setaria anceps*, *Cenchus ciliaris* and *Pennisetum purpurem* of the same age (Holmes *et al*., 1976). However, the rate of disappearance of *Imperata* in digestion bags, although slower than that of other grasses, does not decline as rapidly with time of digestion. This can probably be attributed to a higher degree of lignification of *Imperata* rendering digestible material less accessible to fermentation but allowing digestion to continue for a longer period at a slower and more constant rate. This slow rate of digestion is found even with young *Imperata* forage. Rate of passage directly affects intake, which, on a diet of poor quality actually needs to increase, therefore animal production from *Imperata* would be expected to be lower than that obtained from the other tropical grasses.

The productivity of cattle grazing *Imperata* has also been studied by Holmes *et al*. (1976) with three groups of heifers at four stocking rates on four pastures over a period of 22 months. The study was a comparison between an *Imperata* pasture, an *Imperata* and legume pasture, a Hamil grass (*Panicum maximum*) pasture fertilized with nitrogen and a Hamil grass and legume mixed pasture. They recorded liveweight gains of 0.22, 0.25, 0.21 and 0.20 kg day^{-1} at the stocking rates of 1.29, 1.06, 0.83 and 0.61 ha $beast^{-1}$, for heifers grazing the *Imperata* pasture as compared with the highest weight gain of 0.45 kg day^{-1} for heifers grazing the Hamil grass and legume mixed pasture at stocking rates of 0.59, 0.46 ha $beast^{-1}$. Inclusion of a legume in *Imperata* pasture increased productivity except at the higher stocking rates. From this experiment Holmes *et al*. (1976) concluded that *Imperata* in Papua New Guinea is deficient in nitrogen or digestible energy.

Soewardi and Sastradipradja (1976) recorded liveweight gains of 0.14 kg day^{-1} on *Imperata* of 60.9% dry matter digestibility and 66.9% digestible organic matter. When supplemented with

urea, carbohydrate sources, salt, bone meal and trace elements, the mean liveweight gain was 0.21 kg day^{-1}. On an *Imperata* diet supplemented with cassava meal, a liveweight response above unsupplemented *Imperata* was recorded. This diet contained a lower crude protein content and a higher TDN, which led Soewardi and Sastradipradja (1976) to suggest that the response was due to the additional energy provided by the cassava meal. Concentrations of ammonia-nitrogen in rumen fluid were 13.27 mg 100 ml^{-1} for cattle on an *Imperata* diet, 11.99 mg 100 ml^{-1} when that diet was supplemented with urea, and 5.19 mg 100 ml^{-1} when supplemented with cassava. This is suggested to be supportive evidence that the primary deficiency of *Imperata* was energy. It is of interest to note that the highest correlation coefficient derived from data arising from this study was between liveweight change and dry matter intake.

In another experiment, Soewardi *et al*. (1975) compared *Imperata* of 7.7% crude protein content with Napier grass (*Pennisetum purpureum*) of 8.1% crude protein content. They found that cattle on the *Imperata* diet showed higher voluntary intakes and liveweight gains and lower rumen ammonium nitrogen levels.

In the Philippines, Magadan *et al*. (1974) recorded liveweight gains of cattle grazing *Imperata* at a stocking rate of 1.0 beast ha^{-1} as 100 kg $year^{-1}$ (0.27 kg day^{-1}) whereas on improved pastures based on para grass (*Brachiaria mutica*) and *Centrosema pubescens*, productivity per hectare was more than three times this figure.

The growth rates of cattle on farms in Papua New Guinea were also studied by Holmes *et al*. (1976) who noted large variations between properties due to a widespread sodium deficiency and variable reactions toward remedying this deficiency. Liveweights also varied according to the amount of feed available. For nine to ten month old calves, liveweight gains ranged from 0.39 to 0.69 kg day^{-1} while for heifers to two years of age the range was 0.27 to 0.39 kg day^{-1} and for steers to 450 kg liveweight, the range was 0.26 to 0.39 kg day^{-1}; to attain these liveweight gains, the authors believe that some other plant species must also have been grazed. Calving percentages varied from 62 to 100 and from 75 to 100 for heifers and cows respectively.

As a general conclusion from these studies it can be stated that while usually viewed as a noxious weed, *Imperata* can support cattle at slow rates of liveweight gain. For higher rates of liveweight gain the common approach is to replace *Imperata* with species more suited to grazing (Gibson, 1976). In terms of the development of grazing industries, utilization of *Imperata* until it declines in productivity has been recommended before eventual replacement with legume based pastures in Papua New Guinea (Bunning, 1975). Means of utilizing *Imperata* pasture more efficiently through supplementation of deficient nutrients have not been investigated in any detail over wide areas.

Determination of Utility

The total area of *Imperata* in the mountains of northern Thailand has been estimated to be 2,500 square kilometres (Gibson and Van Diepen, 1977). This area is grazed by cattle and buffalo in conjunction with some other animal species at low stocking rates. Productivity of those cattle and buffalo is low, and as any development of the grazing industries would be slow, means of utilizing the natural resource of large areas of *Imperata* more efficiently are required. Research concerning *Imperata* in northern Thailand is presented below.

Establishing the quality of local *Imperata* is critical to understanding for the development of the industry. Sampling of pastures for chemical analysis of nutrients is limited by the subjective nature of the sampling techniques commonly utilized (Corbett, 1978). Nevertheless, cutting of pasture at predetermined intervals does provide an estimate of pasture growth rates and analysis of these samples does provide an estimate of pasture quality over the year. Analysis of grab samples is similarly useful in providing an estimate of the quality of the plant material selected by cattle. Chemical analysis of cattle faeces has also been suggested as a means of estimating digestibility, feed intake and other parameters (Lancaster, 1959), although the most useful analyses are probably those for nitrogen through its association with liveweight gain (Winks *et al*.,1977a) and phosphorus, because little phosphorus is lost from the body by any route other than faeces (Townes *et al*.,1978).

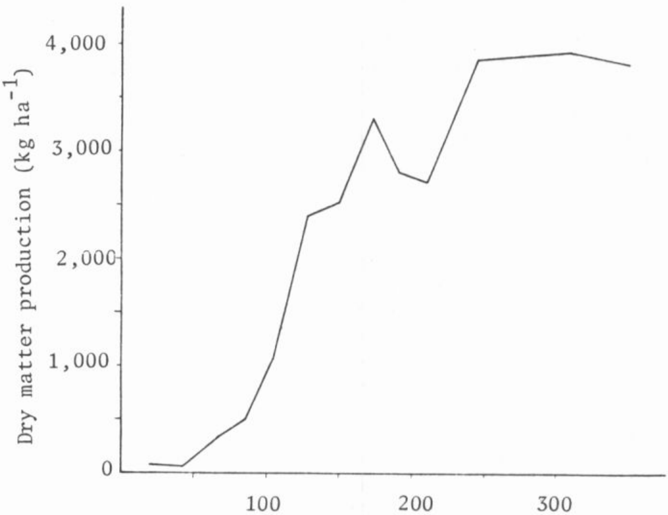
Perhaps the most useful estimate of the quality of pasture selected by cattle is obtained by the use of oesophageally fistulated cattle. Oesophageal fistulation was first used as a nutritional technique by Torell (1954) and is now utilized as a reasonably standardized technique (Van Dyne and Torell, 1964). The obvious advantage of the technique over hand sampling of pasture is that the sample obtained is that portion of the pasture selected by the experimental animal, however it cannot be assumed that these samples are truly representative due to variations between animals, days and the limited sampling time necessarily utilized (Langlands, 1967). Boluses collected from oesophageally fistulated cattle can be analyzed to predict the nitrogen content (Little, 1972a) and, with a lower degree of accuracy, *in vitro* digestibility (Corbett, 1978) of herbage grazed. Mineral nutrients in the feed including sodium, phosphorus, molybdenum, manganese and zinc cannot be reliably predicted by the technique due to the salivary contamination (Little, 1975).

Apart from pasture dry matter production and nutritional quality, the stability of grazing lands with respect to invasion by unpalatable weeks may also affect animal productivity. Invasion of *Imperata cylindrica* swards by weeds of the *Eupatorium* genus renders native pastures less accessible to grazing around some highland villages. Factors affecting this invasion have not been defined although casual observations indicate that invasion is more severe in areas that have been grazed for longer periods of time. An increasing tendency to overgraze

due to low feed availability, increasing numbers of stock and decreasing availability of land over recent years may have increased the rate of invasion.

Agronomic Productivity and Quality

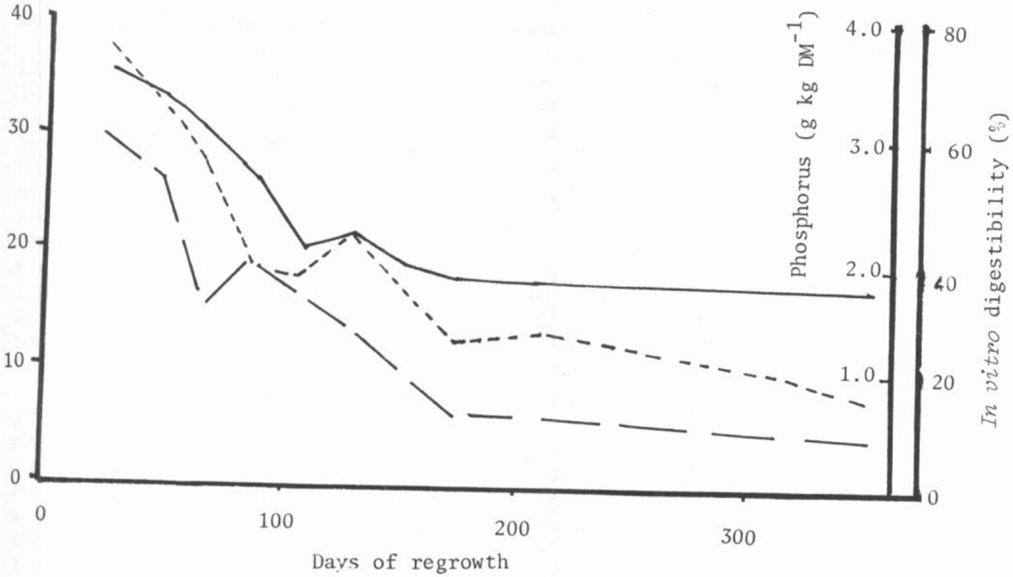
The mean production of green material of Imperata in northern Thailand over one year is presented in the following figure. Mean green matter production reached a peak of 3,920 kg ha^{-1} in January although little additional growth was recorded after the end of the wet season (October). The mean green matter production of the five year old sward was 4,190 kg ha^{-1}.



Dry matter production of *Imperata cylindrica* over one year

Nitrogen and phosphorus content and in vitro digestibility values of the harvested samples are shown in the following figure. Nitrogen content of the harvested samples declined from 29.3 to 5.6 g kg DM^{-1} while phosphorus declined from

3.7 to 0.9 g kg DM^{-1} and in vitro digestibility declined from 71.4 to 37.4%. Nitrogen, phosphorus and in vitro digestibility values for the five year old sward were 6.6 g kg DM^{-1}, 1.2 g kg DM^{-1} and 31.4% respectively.



Nitrogen content (—— –), phosphorus content (---) and *in vitro* digestibility (____) of *Imperata cylindrica* over one year.

The green matter production of plots reharvested for the first time on the dates 11 July 1978, 14 November 1978 and 14 March 1979 is presented in the following table, together with data for the nitrogen and phosphorus contents and in vitro digestibility. The rate of regrowth appeared to be highest for plots harvested on 14 November 1878 while nitrogen, phosphorus and, to a lesser extent in vitro digestibility, values were highest for early wet season regrowth (11 July 1978) and lowest for dry season regrowth (14 March 1979).

Estimated mean values of dry matter production, nitrogen content, phosphorus content and *in vitro* digestibility for *Imperata cylindrica* regrowth to three dates.

Harvest date	Age of Regrowth	Dry matter (yield(kg ha^{-1})	Nitrogen (g kg DM^{-1})	Phosphorus (g kg DM^{-1})	In vitro digestibility (%)
11/7/78	20	220^{ab}	19.5	2.7	50.6
	40	160^{a}	21.0	2.3	51.8
	60	280^{cd}	19.5	2.4	50.3
	80	520^{f}	16.5	2.3	44.7
14/11/78	22	240^{bc}	10.5	2.8	51.0
	40	280^{cd}	16.0	2.7	52.4
	60	450^{e}	15.5	2.1	49.6
	80	690^{g}	12.5	1.7	46.4
	100	760^{h}	10.0	1.6	45.0
14/3/76	40	200^{ab}	10.5	1.3	44.5
	60	320^{d}	10.0	1.2	43.2
	80	440^{e}	9.7	1.1	42.0
	100	570^{f}	8.5	1.0	40.8
	LSD	61			

Means within a column followed by the same superscript do not vary significant (P >0.05).

Dry matter production to 14 November 1978 for plots reharvested for the second time varied from 461 to 743 kg ha^{-1} from the 126 day regrowth period. Rate of dry matter production decreased with the number of successive harvests. Nitrogen content varied from 10.1 to 11.1 g kg DM^{-1},phosphorus content from 1.4 to 1.5 g kg DM^{-1} and in vitro digestibility from 42.0 to 49.8%.

Dry matter production to 14 March 1979 for plots reharvested for the second time was lower than that of comparable plots that regrew during the wet season (to 14 November 1978). Values ranged from 207 to 407 kg ha^{-1} for the 120 day regrowth period. Nitrogen content varied from 7.2 to 10.8 g kg DM^{-1}, phosphorus content varied from 0.9 to 1.3 g kg DM^{-1} and in vitro digestibility from 40.4% to 45.6%. For those plots that were reharvested for the third time at this date, dry matter production varied from 207 to 552 kg ha^{-1}, nitrogen contents from 8.0 to 12.6 g kg DM^{-1}, phosphorus contents from 1.9 to 1.3 g kg DM^{-1} and in vitro digestibility from 38.1% to 44.8%.

The rate of growth of *Imperata cylindrica* was slower than that of other regions despite similar soils and rainfall to many areas, possibly because the Thai highlands are cooler than those other areas. In New Guinea (Holmes *et al*.,1976), cutting at 12 weeks produced a mean of 320 kg DM week^{-1} compared to 42 kg DM week^{-1} in northern Thailand; the highest cutting frequency in the New Guinea study of four weeks produced a mean of 152 kg DM week^{-1} compared to 20 kg DM week^{-1} in Thailand.

Lower rates of growth of *Imperata cylindrica* would necessitate lower stocking rates than those recorded in New Guinea (Holmes *et al*., 1976), the Philippines (Magadan *et al*., 1974) and Indonesia (Soewardi and Sastradipradja, 1976) which were 0.61 and 1.29, 1.0 and 0.2 beasts ha^{-1} respectively. A simple comparison suggests that *Imperata cylindrica* grows approximately eight times slower in the Thai highlands than that studied by Holmes *et al*. (1976) in New Guinea; it may thus be suggested that stocking rates should be correspondingly lower. This would yield figures of 0.08 to 0.16 beasts ha^{-1} which is similar to the range of 0.04 to 0.14 beasts ha^{-1} that have been recorded in the highlands (Ashfaq, 1975; Snook, 1975).

In vitro digestibility of *Imperata cylindrica* declined to maturity (150 days) at a rate of 0.2% units day^{-1} which is comparable to that of the improved grasses studied by Minson (1971). No comparative data for *Imperata cylindrica* was available but it is expected that *in vitro*, digestibility may also decline less rapidly in the highlands than in more tropical areas due to the effect of temperature in delaying physiological maturity and so affecting digestibility (Minson and McLeod, 1970). Cattle grazing native pastures may select a diet of greater than 50% digestibility throughout the year and the analyses of samples collected from oesophageally fistulated cattle support this contention with the exception of the anomalous figure for the hot-dry season which indicates that cattle graze mature herbage as well as the young regrowth of burned pastures in the late dry-season (March) possibly because the availability of regrowing herbage is low.

Nitrogen contents of *Imperata cylindrica* were approximately twice as high as those recorded in New Guinea (Holmes *et al*., 1976) at the same age. *Imperata cylindrica* in the highlands was above the level of 11.0 gN kg DM^{-1} which is accepted as the minimum necessary for maintenance in steers (Milford, 1960; Milford and Minson, 1965), for a period of about 20 weeks whereas the New Guinea pasture declined below this figure by six weeks. Regrowth during the wet season after the first cutting in Experiment 4 produced forage with nitrogen contents above 11.0 g kg DM^{-1} however regrowth during the late wet season was only above this level for a period of approximately five weeks and dry season regrowth was always below this level. The nitrogen content of *Imperata cylindrica* in the highlands thus appeared to be adequate for about six months of the year. The other native plants studied also contained nitrogen at levels

higher than 11.0 g kg DM^{-1} except for some species during the hot dry season and the samples collected from oesophageally fistulated cattle (see following table) suggest that the nitrogen content of the diet of cattle grazing native highland pastures is not usually limiting. The faecal nitrogen figures similarly indicate that nitrogen content of the diet was usually adequate, because values were above the range determined by Winks _et al_. (1977a) of 12.8 to 13.6 g kg DM^{-1} as being the level below which liveweight losses occur in steers, on all but two occasions during the late dry season.

Mean nitrogen content, _in vitro_ digestibility, number of bites per minute and bite size for native pasture samples collected by oesophageally fistulated cattle at four seasonal periods.

Seasonal Period	Measurement: Nitrogen (g kg DM^{-1})	In vitro digestibility (% DM)	No.of Bites (min^{-1})	Bite size (g DM)
Mid-wet season	18.3^{a}	57.4^{ab}	6.0^{b}	0.35^{b}
Late-wet season	12.1^{b}	40.6^{c}	10.6^{a}	0.44^{b}
Cool-dry season	12.7^{b}	62.5^{a}	6.4^{b}	0.67^{a}
Hot-dry season	15.4^{b}	48.0^{bc}	11.8^{a}	0.67^{a}

Means within a column followed by the same superscript do not vary significantly ($P > 0.05$).

Phosphorus contents of _Imperata cylindrica_ were above the suggested critical level for non-lactating stock of 1.8 g kg DM^{-1} (Cohen, 1975) for similar periods that the nitrogen levels exceeded 11.0 g kg DM^{-1}. Recent research (Little, _pers. comm._) suggests that the minimum required level for maintenance may be 1.2 g P kg DM^{-1} in which case phosphorus levels appeared to be adequate at most times. The phosphorus contents of species studied in Experiment 5 exceeded 1.2 kg DM^{-1} in every case and the faecal phosphorus levels were higher than values recorded for cattle grazing mative pasture in Australia (Winks _et al_., 1977b). Moir (1966b) states that a primary nitrogen deficiency may preclude a response to a phosphorus supplement under phosphorus deficient conditions; the generally high phosphorus levels and the coincidence of low nitrogen levels at that time when phosphorus levels decline suggest that phosphorus is probably not limiting in native pastures.

Levels of sodium were below the suggested minimum required for maintenance of 1.0 g kg DM^{-1} (N.R.C., 1970), for most of the samples analyzed in Experiment 5; it is therefore possible that low sodium levels in native pasture may limit cattle productivity from native pastures.

Feed Intake of Cattle Grazing Native Pastures

The slow rate of regrowth of *Imperata cylindrica* in the highlands as determined from Experiment 4 may limit feed intake of cattle grazing on native pastures despite their adequate nutritional quality. The estimates of feed intake calculated from faecal excretions and the *in vitro* digestibilities of oesophageal extrusa samples expressed as a percentage of body weight, indicate that feed intake never reached the suggested maximum for feed intake of 3% of body intake (N.R.C., 1970) and was particularly inadequate during the late-wet season and the hot-dry seasons (see following table). Decreased grazing time in the late wet season in response to high rainfall intensity and in the hot-dry season in probable response to low digestibility probably caused low feed intakes.

Mean faecal excretion, feed intake, body weight and daily feed intake as a percentage of body weight for four seasonal periods.

Seasonal Period	Faecal excretion (g DM day^{-1})	Feed intake (kg DM day^{-1})	Mean Body Weight (kg)	Intake as % body weight
Mid-wet season	1451[a]	3410	150	2.3
Late-wet season	1312[a]	2210	170	1.3
Cool-dry season	1745[b]	4650	186	2.5
Hot-dry season	1440[a]	2770	182	1.5

Means within the columns followed by the same superscript do not vary significantly ($P > 0.05$).

Bite size is one component of grazing rate and Stobbs (1973a) has noted that it may limit herbage intake on some tropical pastures; the degree of limitation depends primarily on leafiness and accessibility of the sward (Stobbs, 1973b). Bite size and rate in Stobbs' studies refers to the sum of prehension and masticatory bites with the head down while those determined in this study refer only to prehension bites. Chacon *et al*. (1976) recorded that the proportion of masticatory bites with the head down was consistently between 6 and 11 percent of the total. Stobbs (1973a) calculates that bite sizes of less than 0.3 g OM limit intake due to the physical daily limitation of the maximum number of bites of 36,000 in the case of Jersey cows. Cattle in the highlands have access to grazing for approximately nine hours per day thus their maximum number of bites may be reduced to 13,500 per day or, if only prehension bites are considered 12,015 to 12,690 per day, i.e. a mean of 22.3 bites per minute. Biting rates recorded in these studies were always below this theoretical limit and bite sizes were always below the level of 0.8 g OM (0.85 to 0.90 g OM corrected for prehension bites only) calculated by Stobbs (1973a)

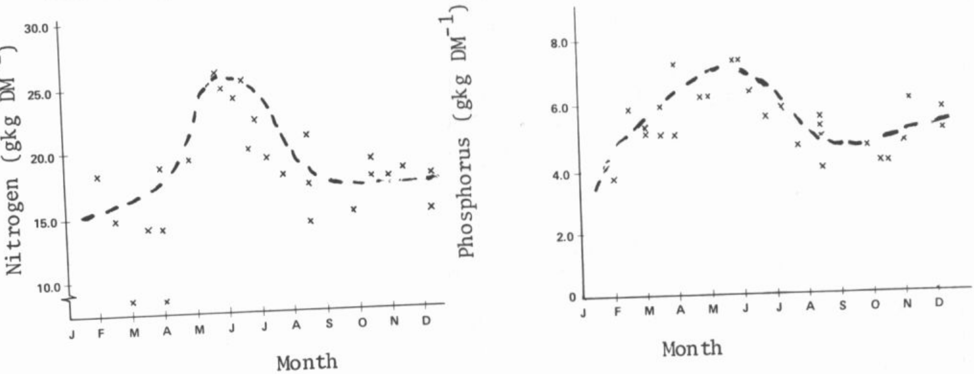
to be minimal for adequate feed intake at biting rates of that order. This supports the results of the chomium sesquioxide faecal study in suggesting that feed intake of highland cattle is limiting; under the constraint of limited grazing time, intake may be restricted by the low digestibility of native pasture or specific nutrient deficiencies.

Other Species in Imperata Grasslands

Species, other than Imperata cylindrica grazed by cattle included: Bothriochloa glabra, Phragmitis kerka, Digitaria ciliaris, D. longiflora, Eragrostis elongata, E. burmanica, E. gigantica, Setaria plicata, S. palmifolia, S. pallide-fusca, S. geniculata, Panicum montanum, P. sarmentosum, Microstegium vagans, Neyrandia reynandiana, Carex baccans, Thysanolaena maxima, Fimbristylis dichotoma, Desmodium hetero-carpon, Cyperus cyperoides, C. brevifolius, Paspalum orbiculars, P. distichum, P. longifolium, Cynodon dactylon, Eleusine indica, Otachloa nodosa, Isachaemum barbatum, Sacciolepsis indica, S. Angusta, Coetorhachis khasiania, Alloterpsis semialata, Polygonium chinense, Stellaria saxatilis, Vibernum inopinatum, Malastoma normale, Erechtites hieracofolia, Gnaphalium affine, Musa spp., Commelina spp. and Bambusa spp.

The species most commonly selected by cattle were: Stellaria saxatilis, Cyperus spp., Microstegium vagans, Commelina spp., Vibernum inopinatum, Polygonium chinense, Sacciolepsis angusta, Carex baccans, Thysanolaena maxima, Panicum spp., Paspalum spp., Cynodon dactylon, Setaria palmifolia, Bambusa spp. and Musa spp. The ranges of nitrogen, phosphorus, sodium and in vitro digestibility values for those species as sampled throughout the year and the percentage of samples above the suggested critical levels for nitrogen, phosphorus and sodium are presented in the following table.

Curves for the nitrogen and phosphorus contents of cattle faeces from cattle consuming this diet are presented in the following figure. In general, trends in these values follow the same pattern with high values corresponding to the early wet season and lower values to the dry season.



Yearly faecal nitrogen and phosphorus levels of highland cattle.

The ranges of nitrogen, phosphorus, sodium and *in vitro* digestibility levels and the proportion above critical levels for native species.

Month	Number of species	Nitrogen		Phosphorus		Sodium		*In vitro* digestibility
		Range (g kg DM-1)	% above critical	Range (g kg DM-1)	% above critical	Range (g kg DM-1)	% above critical	Range (%)
January	12	6.0-23.5	83	1.3-3.6	58	0.2-0.4	0	
February	9	10.5-28.0	89	1.8-2.6	100	0.2-1.4	20	32-60
May	10	10.5-37.0	90	1.5-3.1	70	0.1-0.7	0	39-69
June	10	12.0-31.3	100	1.3-4.2	60	0.4-0.5	0	58-73
July	15	18.3-36.3	100	1.5-4.7	87			37-62
August	7	19.5-32.5	100	1.7-3.0	86	0.6-1.5	58	
October	6	15.5-36.0	100	2.5-3.6	100	0.3-0.8	0	26-68
December	11	8.0-35.3	91	1.3-3.6	55	0.3-0.6	0	

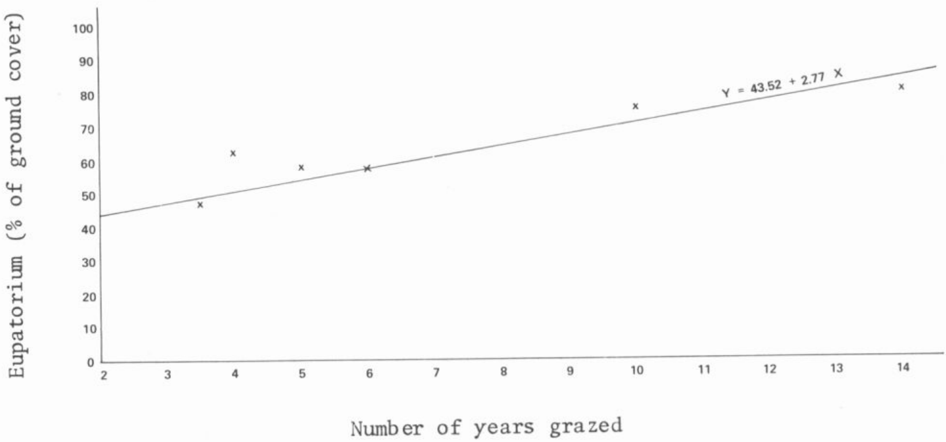
Critical levels: Nitrogen 11.0g kg DM^{-1} (Minson, 1971)
Phosphorus 1.8 g kg DM^{-1} (Cohen, 1975)
Sodium 1.0 g kg DM^{-1} (N.R.C., 1970)

Eupatorium Invasion in Native Pastures

Invasion of *Eupatorium* species into *Imperata cylindrica* pastures is apparently related to grazing pressure which would be expected to decrease with increasing distance from a village to which cattle usually return each evening. Variations between villages can be related to the duration of the grazing pressure, as indicated by the following figure.

The simple correlation coefficients calculated from village data also indicate that the principal factors related to *Eupatorium* invasion are distance, grazing pressure and years of sustained grazing. Distance is a determinant of grazing pressure and the highly significant relationships between the product term of "number of years grazed" and "estimated average stock numbers per year" indicates further that pressure and duration of grazing are the more important factors.

It is possible to speculate on the role of *Eupatorium* in the changing environment of highlands of northern Thailand in the light of this data and other work. *Imperata* often populates deserted swidden sites and is maintained by annual fires (Ivens, 1975), but can easily become dominated by *Eupatorium* species under moderate rates of grazing pressure in the highlands. Regular removal of villages in response to exhausted soils has precluded any great effect of *Eupatorium* invasion of animal production. It is worthy of note that in these circumstances *Eupatorium* invasion was not the prime reason for village removal as it apparently has been in other countries (Holm *et al*., 1977). The abandoned sites are populated by *Eupatorium* which spreads over the deserted house sites and roads and are then apparently less fire prone than is *Imperata*, thereby providing an environment suitable for forest regeneration. In the more tropical environment of Indonesia Eussen (1976) has noted that *E. odoratum* can form the first stage from *Imperata* dominance to secondary forest.



The mean proportion of *Eupatorium* around six villages where grazing had been imposed for various periods

As the forest becomes established, the shading effect of trees would probably lead to a decrease in vigour of the *Eupatorium* due to its high requirement for light (Ivens, 1975) and eventually to complete or near complete disappearance of *Eupatorium*.

Higher land pressures in the highlands have necessitated shorter fallow periods leading to less frequent removal of villages. *Eupatorium* invasion therefore becomes a potential problem of animal production. At the present time however, this degradation of pastures is probably not limiting productivity.

In summary, it may be said that *Imperata cylindrica* in the northern Thai highlands remains above recommended minimum levels for major nutrients and grows slower in the highlands than it usually does elsewhere and that the diet of highland cattle is probably adequate in nitrogen and phosphorus while low in sodium. Feed intake is low and apparently associated with restricted grazing times, through specific nutrient deficiencies or low pasture digestibility. Invasion of native pastures is related to grazing pressure but is probably not limiting cattle productivity.

CHAPTER 4

Sociology of the Highlands

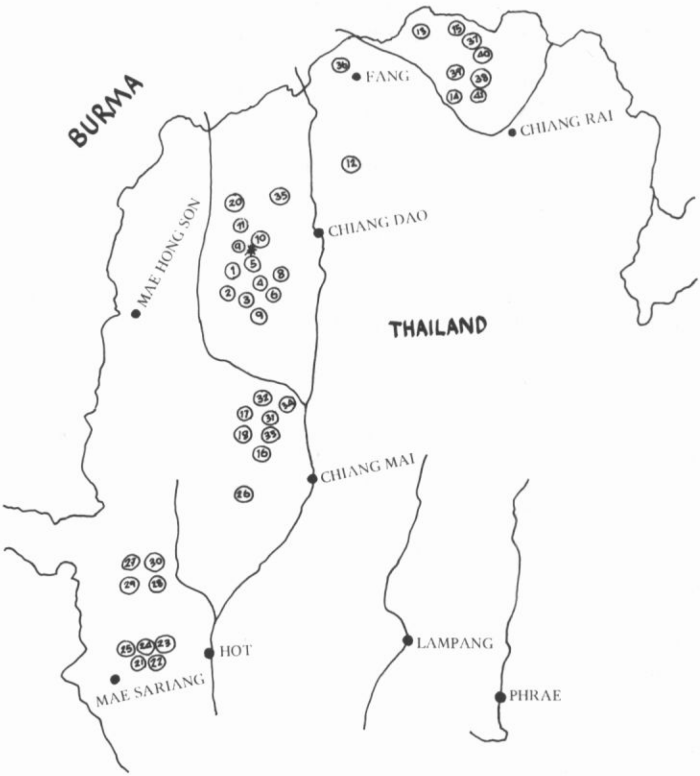
INTRODUCTION

Development of the highland cattle industry relies on an understanding of the existing structure of ownership and attitudes of the people owning livestock. The inaccessibility of the area favours development on a small holder or present resident basis. Information concerning the existing industry was gained from some 42 villages presented in the following table and map.

Tab

List of villages surveyed, their ethnic composition, altitude, size and main source of income.

Number	Village (Thai Name)	Ethnic (group)	Altitude (m)	Amphoe	Number of households	Main Source of income
1	Ton Kham	Khon Muang	500	Mae Taeng	26	wet rice
2	Mac Ta Man	Khon Muang	360	Mae Taeng	131	wet rice
3	Thung La Khon	Khon Muang	400	Mae Taeng		
4	Pang Mae Ta Man Nok	Khon Muang	680	Mae Taeng	10	miang
5	Pang Mae Ta Man Nai	Khon Muang	800	Mae Taeng	11	miang
6	Phapujom	Meo	930	Mae Taeng	23	opium
7	Huai Tad	Lahu	900	Mae Taeng	31	agricultural products
8	Mae Mae	Lahu	1,300	Chiang Dao	10	opium
9	Mae Kok I+II	Meo	1,350	Chiang Dao	3	opium
10	New Pa Kia	Meo	1,500	Chiang Dao	12	opium & potatoes
11	Old Pa Kia	Meo	1,320	Chiang Dao	29	opium & potatoes
12	Mae Pun Luang	Lahu	1,325	Viang Pa Pao	43	opium
13	Pha Duea (Lao Si)	Yao	600	Mae Chan	45	corn and sesame
14	Doi Yao	Yao	500	Chiang Rai	32	corn and sesame
15	Pha Mi	Akha	600	Mae Sai	72	opium
16	Yang Ha	Karen	1,060	Samoeng	30	rice
17	Pang Kia	Karen	1,100	Samoeng	17	rice
18	Pang Klung	Karen	1,000	Samoeng	6	rice
19	Mae Chang	Karen	800	Mae Sariang	30	rice
20	Sam Muen	Lisu	1,350	Chiang Dao	64	opium
21	Mae Tho	Meo	1,100	Hod	24	opium
22	Boa Lek	Meo	1,200	Hod	22	opium
23	Lao Lee	Meo	1,150	Hod	13	opium
24	Lic Doi	Meo	1,200	Hod	3	opium
25	Mae To Luang	Karen	1,050	Hod	30	rice
26	Khun Wang	Meo	1,320	San Pa Thong	20	opium
27	Pui Pu Lee	Meo	1,300	Mae Chaem	12	opium
28	Huai Hin Fon	Meo	1,250	Mae Chaem	13	opium
29	Pui (key village)	Meo	1,400	Mae Chaem	27	opium
30	Pui (Karen)	Karen	1,200	Mae Chaem	22	rice
31	Pong Khrai	Khon Muang	1,000	Mae Rim	27	miang
32	Pang Luang	Khon Muang	1,160	Mae Rim	20	miang
33	Buak Jam	Meo	1,280	Mae Rim	35	opium
34	Nong Hoi	Meo	1,300	Mae Rim	47	opium
35	Na Law	Lisu	8-900	Chiang Dao	58	opium
36	Khob Dong	Lahu	1,450	Fang	24	opium
37	Saen Jai Mai	Akha	680	Mae Chan	33	rice
38	Law Sii Kuay	Yao	620	Mae Chan	24	rice
39	Ja Phuu	Lahu	660	Mae Chan	23	rice
40	Saen Sok	Akha	580	Mae Chan	34	rice
41	Huey Kang Plaa	Yao	560	Mae Chan	19	rice
42	La Pa Ta	Lisu	900	Mae Taeng	25	opium



Location of villages included in surveys

(numbers refer to villages designated in Table

OWNERSHIP OF LARGE RUMINANTS

Highlanders become cattle or buffalo tenders either by buying stock, by tending stock on agistment, by receiving stock as a gift or by inheritance. Purchase of cattle represents a large investment for a highland dweller whose annual income may be of the same order as the cost of one beast (Hoare et al., 1977). In one instance a resident of the Meo village, Ban New Pa Kia sold potatoes to the value of 4000 baht which he then used to buy cattle, although normally such funds would come from the sale of opium. Cattle and buffalo are accepted on agistment on the basis that every second calf becomes the property of the tender, thereby allowing the tender of the stock to become a stock owner himself. Wedding presents of cattle from a father to his new son-in-law occur although inheritance of livestock is the most common means by which villagers become cattle owners, particularly in the more stable villages.

The most common reason that cattle and buffalo are raised is as a means of insurance against crop failure. At some Lisu villages, owners are not prepared to sell cattle at market prices unless they encounter financial hardship and find it necessary to supplement their income by the sale of some livestock. Large ruminants are also tended for work purposes; in the case of cattle for transportation of miang and possibly other crops, and in the case of buffalo for cultivation of paddy fields in the lower altitudes. Cattle and buffalo are viewed as a means of producing regular income only in villages in close proximity to the lowlands. The animistic beliefs of some ethnic groups require the sacrifice of varying numbers of large ruminants upon the death of certain persons. Slaughter solely for meat consumption is rare being restricted primarily to feast days and badly injured animals.

The cattle and buffalo populations, and factors related to the distribution of ownership within some villages are presented in the following table. Correlation coefficients between cattle and buffalo ownership and the consumer to work ratio per household (that is, the number of persons to be provided for in a household relative to the number of persons capable of producing) were low and not significant ($P > 0.05$). The relationship in many cases is confounded by the division of livestock between children after the death of parents. Stock ownership of the recipient family is therefore not necessarily a function of the consumer to worker ratio of that family. In instances where cattle are donated by organizations promoting highland development, stock are usually given to persons who do not already own cattle thereby rendering the consumer to worker ratio irrelevant. Buffalo ownership tends to be more evenly distributed than that of cattle, possibly because buffalo are often owned specifically for cultivation purposes, especially among the Karen. Thus one would expect a relationship between buffalo ownership and ownership of paddy lands.

Cattle and buffalo ownership and distribution of ownership in individual villages, presented in ethnic groupings (including stock on agistment).

Village name and ethnic group	Cattle population	Number of households owning cattle	Buffalo population	Number of households owning buffalo	Percent of households owning cattle or buffalo	Percent of the cattle and buffalo herd owned by the largest owner
Khon Muang						
Ton Kham	28	11	29	10	54	19
Mae Ta Mae & Tung La Khon	67	3	–	–	45	9
Pang Mae Ta Man Nok	20	3	–	–	30	40
Pang Mae Ta Man Nai	34	4	–	–	36	41
Pong Khrai	27	4	24	13	56	27
Pong Lung	28	7	–	–	35	29
Karen						
Yang Ha	50	11	131	22	73	9
Pang Kluay	13	1	41	5	83	55
Mae Chaem	38	8	45	13	57	19
Mae To Luang	41	5	155	25	87	14
Pui (Karen)	103	12	43	10	64	19
Meo						
Phapu jom	31	12	1	1	48	26
Mae Kok I	22	3	–	–	100	55
Old Pa Kia	53	10	–	–	38	28
New Pa Kia	14	5	6	2	50	35
Mae To	142	15	10	2	75	23
Boa Lek	62	13	4	1	59	24
Lao Lee	113	11	18	3	85	31
Lei Doi	12	3	–	–	100	58
Khun Wang	119	11	11	3	60	28
Pui Pu Lee	79	6	–	–	50	70
Huai Hin Fon	161	9	2	1	69	37
Pui (Key Village)	145	19	12	3	44	21
Buak Jam	19	3	2	1	9	52
Nong Hoi	141	23	37	11	57	11
Lahu						
Huai Tat	21	5	–	–	16	24
Mae Mae	55	4	–	–	44	49
Mae Pun Luang	165	28	61	16	65	14
Khob Dong	62	7	6	1	29	31
Ja Phuu	–	–	44	20	87	9
Yao						
Pha Deua (Lao Si)	34	2	64	19	42	29
Doi Yao	–	–	31	11	34	19
Law Sii Kuay	–	–	18	8	33	22
Huay Kang Plaa	12	2	2	1	11	57
Lisu						
Doi Sam Muen	225	31	15	4	48	9
Na Law	200	14	0	0	24	25
La Pa Ta	200+	5	0	0	20	40
Akha						
Pha Mai	48	1	200	30	42	36
Sae Jai Mai	41	8	–	–	24	29
Saen Suk	–	–	58	9	27	26

Greater cattle populations encountered in Lisu villages indicate the attitude of the Lisu toward cattle who view them primarily as a financial reserve to be drawn on in times of need. The lowest average cattle population per village are found in Yao villages which may reflect the changing station of the Yao as they strive to enter the lowland economy where the possibilities of raising large numbers of cattle are restricted. Low populations of cattle in Akha villages are related to their preference for buffalo for use in paddy fields.

Mean buffalo populations are highest in Akha villages, followed by Karen, Yao and then Lahu. This order of ethnic groups approximates the order to paddy field cultivation among these ethnic groups. In the case of the Akha tribe, some tending of buffalo for leasing to lowland areas for paddy field cultivation also occurs. The other three ethnic groups: Khon Muang, Meo and Lisu have similar buffalo populations.

In terms of the mean percentage of households tending cattle or buffalo per village, the Karen ethnic group, where paddy field cultivation is of importance to most households, have the highest proportion. The Karen own buffalo primarily for the cultivation of paddy fields rather than as a cash reserve. Thus ownership tends to be more evenly distributed. The concentration of ownership of large livestock in Akha, Yao and Lisu villages most probably reflects a greater disparity of wealth within these villages than within villages of the other ethnic groups especially the Karen.

Another means of investigating the distribution of cattle or buffalo ownership is to express ownership as a percentage of the herd tended by the largest stock holder. On this basis, the range of results is surprisingly low (about 20%). Lower concentrations of ownership per household were encountered in Lisu villages where the large stock populations are spread fairly evenly among the stock owners.

Grouping on an ethnic basis does not reveal any large differences between the groups and, for the most part, individual villages seem to follow the same trend. Most households have cattle or buffalo populations of less than five head. The mean distributions of ownership by household indicate that the most common herd size for a household is two head of cattle or buffalo which represents a cow and her most recent calf or draught animals.

ATTITUDES TOWARD LARGE RUMINANTS

Large differences between ethnic groups in their attitudes to agriculture and economics have been noted (Wongsprasert, 1977) and Keen (1972) has illustrated this with an example of economic loss associated with the keeping of livestock purely as a reserve against financial hardship.

The principle ethnic group resident in the highlands are Khon Muang, Karen, Meo, Lahu, Yao, Lisu and Akha. Differences between these groups are probably decreasing as contact both between them and with the more developed lowland regions increase with improved road access and radio contact. The following discussion summarizes information pertaining to large livestock on an ethnic group basis.

Khon Muang

The population of the Khon Muang resident in the highlands has not been determined but is declining amongst miang producers (Hoare and Thanyalipitak, 1979). Those practising wet rice cultivation do not vary markedly from their lowland counterparts and in fact any division between the two is made on arbitrary geographical grounds. Buffalo are kept for paddy field preparation and to a small extent to pull carts, although cattle are used more widely for this purpose. Cattle and buffalo are often tethered along roadsides and other waste areas or are allowed to graze some crop residues in fields after harvesting is completed. Sale of livestock is usually in response to the limited grazing available near the village. Sales are infrequent however, because predominantly male animals are kept.

Miang producers live at slightly higher altitudes. Cattle and horses have traditionally been used for transportation of miang out of villages. Stock owners in these villages are more obviously affluent than those who did not own stock. Instances of persons borrowing money to purchase cattle for transportation of miang on behalf of other persons occur. The cattle are predominantly castrated males and grazed on the understorey of miang gardens. Cattle are also accepted on agistment in these villages.

Unlike other ethnic groups of the highlands, Khon Maung people do not usually regard cattle as insurance against financial hardship. Other forms of investment are preferred and a commercial attitude toward livestock is common.

Karen

The Karen, who make up about 56% of the total hilltribe population of about 400,000 (excluding Khon Muang) (T.R.C., 1976) keep both cattle and buffalo. Cattle are regarded as insurance against crop failure while buffalo are used to cultivate paddy fields which the Karen commonly construct in the lower altitudes of the highlands. The Karen prefer to raise large ruminants because they require lower management inputs. Instances of persons accepting lower standards of living in order to purchase additional livestock are common and Young (1974) has noted that elephants and buffalo generate the main source of income in some villages.

Meo

The Meo make up about 11% of the hilltribe population (T.R.C., 1976) and are probably the most mobile of the hilltribes. A Royal Thai Government survey in 1965 indicated that 92%

of all households surveyed had moved during the previous ten years (Walker, 1975).

Cattle are kept primarily to fulfil the social obligations involving animal sacrifices upon the death of a parent. Buffalo are kept in some villages for leasing to lowland wet-rice farmers or for use in paddy fields in the lower elevations.

Lahu

The Lahu comprise about 6% of the hilltribe population (T.R.C., 1976). Large differences in attitudes toward livestock are evident within this ethnic group; instances of a primitive belief connecting predator attacks on livestock to adultery occur (Young, 1974).

The elevated design of Lahu houses provide housing for cattle and the close contact between the owner and his stock seems to promote slightly higher levels of management inputs than is common in other hilltribe villages. Instances of culling on the basis of poor fertility are infrequent except in some Christian Lahu villages where schemes to raise cattle on a commercial basis were introduced by missionaries. Among the animistic Lahu, cattle production for direct sale to the lowland draught trade occurs.

Yao

The Yao comprise about 7% of the hilltribe population (T.R.C., 1976) and they are generally regarded to be the most advanced, sophisticated and business-minded ethnic group in the highlands (Young, 1974; Walker, 1975). The Yao are closely associated with the lowland economic community and consequently prefer to reside in the lower altitudes of the highlands where there is little area available for large ruminants. Buffaloes are preferred to cattle under these circumstances because they are useful in paddy field preparation.

Lisu

The Lisu comprise about 4% of the hilltribe population (T.R.C., 1976). Young (1974) has noted that quite large herds of cattle are often associated with Lisu villages. In some Lisu villages cattle herds may number about 300 head. Such large herds often sustain large losses to thieves, predators and diseases.

Akha

The Akha comprise about 3.5% of the hilltribe population (T.R.C., 1976). They keep cattle for sale in cases of financial hardship and buffalo for use in paddy fields, for leasing to lowland farmers and for use as sacrificial animals in funeral ceremonies. Buffalo raising is generally preferred to cattle raising as higher rates of return can be obtained from their leasing to lowland farmers.

SACRIFICIAL USE OF LIVESTOCK

Some ethnic groups raise livestock to fulfil sacrificial obligations. This attitude does not preclude the keeping of stock as insurance or for economic gain, but it does have a great bearing on the development of the industry. The principle tribal groups concerned with the sacrifice of cattle and buffalo are the Meo, the Akha, the Lua and possibly to a minor extent the Lisu. Among the Yao some people claim to remember that sacrifice of large animals was once important but increasing economic importance of large livestock has led to modification of the custom. Pigs and chickens are now the main sacrificial animals while cattle or buffalo may be slaughtered on feast days. Among the Lahu ethnic group, the pig is the largest animal ever sacrificed, as seems also to be the case with the Karen today although in the past larger livestock may have been slaughtered on the death of an owner elder.

Outside Thailand it has been noted that the Shan ethnic group in Burma sacrificed a buffalo and two pigs every year with an especially large celebration every third year. In the Kaw ethnic group in Burma a buffalo, pigs and fowls were sacrificed in funeral celebrations, while in the Kachin ethnic group the equivalent celebration involved several cattle and buffalo (Telford, 1937). There have been some changes since these observations were made, including a decrease in the incidence of all sacrifices particularly those involving large ruminants.

Meo Sacrificial Rites

Funeral rites of the Meo involve the sacrifice of cattle to a large extent. Chindarsi (1977) notes that upon death of a relative, ceremonies must be held in order to send the spirit of the deceased with many domestic animals so that the spirit will not come back to demand gifts of food by making the survivors sick. One reason for polygamy among the Meo is said to be a desire to have many children, especially boys, as this not only adds to the respect paid to the father but also ensures a larger mortuary rite when he dies. Funeral ceremonies vary in size according to: age (larger celebrations for adults than children), sex (larger celebrations for males than females), number of children and relatives, reputation, respect and the wealth of relatives.

The incidence of cattle sacrifices is related to the number of deaths and the wealth of the family concerned. In one village over a one year period a total of at least 21 cattle plus an unspecified number of buffalo have been sacrificed for religious purposes in that village. One incident was recorded which involved the sacrifice of four cattle, one buffalo and five large pigs for the mortuary rites of a senior Meo man (Wongsprasert, 1974).

In Meo villages, cattle, buffalo, pigs and fowls are usually only killed for sacrifice to the spirits or to welcome important guests. An indication of the relative importance of large animal sacrifice can be obtained from some figures

presented for a six month period at one village during which two cattle beasts were killed compared with 125 fowls and 114 pigs (Chindarsi, 1977). The smaller animals are killed more frequently as cures for complaints such as stomach ache, headache and influenza, although in some special cases the requisite cure may be divined to be cattle.

Akha Sacrificial Rites

When an Akha elder dies, one or preferably two buffalo, are sacrificed. In the case of a wealthy family the number of buffalo slaughtered may be greater. All Akha persons wish to observe this custom but a very poor family may not be able to do this. Families not owning any buffalo may borrow money in order to purchase a beast or in special cases the corpse may be stored for up to one year in a semi-sealed coffin until enough capital has been accumulated to purchase a buffalo beast. Such requirements may be waived in the cases of less important persons or poverty. Upon the death of an elder who has become addicted to opium and so consumed the family's residual capital, a pig may be sacrificed instead of a buffalo.

The buffalo meat may not be eaten by members of the household of the deceased. Cattle may also be slaughtered in the funeral ceremonies to provide additional food for guests rather than a sacrifice. The corpse is usually kept in the house for a period of seven days with poultry, pigs and sometimes goats being sacrificed daily; buffalo and cattle are usually killed on the seventh day.

Lisu Sacrificial Rites

It has been stated that Lisu sacrificial customs were similar to those of the Meo (Young, 1974) although sacrificial use of large livestock in Lisu villages is infrequent.

When an elder dies no sacrifice of cattle or buffalo seems to be made although after a period of seven or nine years a ceremony to recall the spirit of the deceased back to his house may be performed. Part of that ceremony may involve the slaughtering of cattle to feed guests at the celebration. The animals are apparently not an essential component of the religious ceremony.

The Need to Sacrifice

There is a general belief among minority ethnic groups in Burma that the souls of animals travel with that of the deceased (Telford, 1937). This belief seems to be widespread among all the tribal groups of the north Thailand highlands who practise sacrificial use of large ruminants. Individuals of both the Meo and Akha groups have indicated a belief in the association of the spirit of the deceased with the spirit of the sacrificed animal. It is believed that there are many similarities between the world and the "spirit world" such that the spirit of a deceased person must require the spirit of animals for food. This belief gives rise to the

reasoning that sickness is a symptom that the spirits of one's ancestors are hungry and require more animal spirits. Hence the need to sacrifice animals in order to relieve sickness.

The Importance of Sacrifices

It has been suggested that meat is only consumed when animals are sacrificed. This appraisal may not apply generally because fried vegetables for example cannot be prepared without fat obtained from the fat pig bred in the highlands. Pigs are killed for fat when required and during other periods when no sacrifices are required, poultry are killed regularly. Thus, while sacrifice of livestock both large and small is an important part of tradition, it is not the sole source of animal protein, although a significantly larger intake of animal protein would be expected when animals are sacrificed. It may be postulated that the additional protein and fat consumed at funeral celebrations may assist the survival of celebrators through a period of stress.

MANAGEMENT

The level of management of livestock by highland dwellers is low; ruminants receiving lower than the already low inputs for poultry and swine.

No additional feed is offered to ruminant livestock. However, horses and mules kept for pack purposes complimentary to the pack purposes of cattle, often receive special treatment in order to maintain them in good condition. Native grass species such as *Thysolaena maxima* are collected and sometimes transported by horseback or on the backs of villagers themselves to the village to feed horses and mules. Salt may occasionally be offered to cattle, buffalo and goats as a means of quieten-ing animals and encouraging them to return to the village each evening although this practice is not common. Villagers in most cases recognized the dry season as the most trying period of the year for livestock but in no cases did they consider this a real problem by itself. In areas where replanting of forests had encroached on cattle grazing lands, villagers recognized feed shortage during the late cool-dry season as an increasing problem. This commonly reflected a concern for crop damage by hungry cattle rather than a concern for the cattle themselves. In the hot-dry season no crops are grown and preparations for future cropping fields which involves burning of large areas produces regrowth of perennial grasses which the cattle graze. In some villages, farmers have their cropping fields extending in one direction from the village while cattle can go out to graze in the other direction in order to minimize crop damage. Gates not necessarily connected to a continuous fence, are some-times erected across paths; deep ditches around fields are also employed to keep cattle out of cropping fields.

Medical treatment is seldom offered to sick or injured stock. Medical treatment is generally offered by villagers themselves; Wounds may be treated with petrol, kerosene or a mixture of plant leaves. The application of a mixture of native

peach tree leaves and dried tobacco leaves to wounds that have become infested by maggots is also practised. All the above medical treatments seemed to be practised to a greater extent by Khon Muang people than by hilltribes.

It is common practice in the highland regions for the cattle to return to the village in the evening, where they may spend between 12 and 17 hours. Cattle may be physically restrained during the night, they may be herded or trained to return to their owner's house but not restrained, or they may simply camp in the common area of the village near the houses. In some villages, cattle do not return to the village every night. Tending of stock during their daily grazing routine also varies markedly. Thefts appear to decrease in proportion to the inputs of tending.

Closer tending of buffalo than cattle seems to be the general rule which possibly reflects both the greater value placed on buffalo and the progressiveness of the buffalo owners. villages where paddy fields are worked and buffalo therefore employed are usually more progressive and have greater contact with lowland civilization which may encourage improved management techniques, but may also increase the need to guard against theft.

Input levels for the tending of stock in the highlands are variable. Often inputs are negligible such that stock can leave the village at will and return at will. This system allows stock to stay away from villages overnight and leads to high stock losses. In other systems, stock may be or may not be tended while grazing but are brought back by the village each night. In intensive cropping areas, uncommon to the highlands, stock are often tethered in unused paddies or roadsides and are usually watched all day while other tasks are being performed. Stock are brought back to the village each night and losses are very rare.

Tending of livestock is usually regarded as a menial task and therefore often assigned to children. Other activities of the agricultural year are regarded as more important than livestock tending and in times of peak labour demands for agricultural work, stock tending may be curtailed. This practice, although placing at risk a considerable investment, is consistent with the general reluctance to sell stock except in times of need. That is, stock are not viewed as an income producing commodity. In some villages labour inputs into stock-tending reflect a large interest in keeping stock out of cropping areas rather than an interest in stock <u>per se</u>.

The distance stock travel from the village of their owners to seek grazing areas depends on the herd size and the quality of grazing available in the area, but is usually within two kilometres. During the dry season, stock may travel up to ten kilometres from a village and may only return occasionally. Estimates of grazing areas of cattle in the highlands such as that of Wongsprasert (1977) which suggests two hectares per head do not refer to the dry season. Areas around villages

where large herds have grazed, have high levels of infestation with the weeds, <u>Eupatorium</u> <u>adenophorum</u> and <u>E</u>. <u>odoratum</u>.

Weaning of calves is not practised in any of the highland villages surveyed. Breeding management of large ruminants is likewise low. Castration practised in some villages is usually performed after the animal has reached sexual maturity in order to ensure a strong, well muscled beast. Thus castration is not used as a management tool for breeding purposes.

In some cases, larger bulls are castrated because villagers have observed cows falling over under large bulls during mating. However, the uncontrolled mating system is more likely at fault through allowing almost continuous mounting of cows on heat thereby tiring them. Castration of heavy bulls is in fact probably less desirable in terms of growth rates and marketability than is more selective castration. Rufener (1971) noted a similar outcome in lowland Thai villages in north-eastern Thailand where larger cattle are castrated to render them more docile. In the case of buffalo in lowland areas, larger males are often castrated leaving only inferior sires. The wider role of castration in management is beginning to be appreciated in the highlands.

Three different methods of castration are practised in the highlands, namely; surgical removal of the testes through a cut in the scrotum, surgical removal of the scrotum and testes, and clamping and hammering two pieces of wood either side of the vas deferens and blood vessels supplying the testes. The latter method is the most common and also the least reliable. Castration operations are performed either by the owner of the animal, or more commonly by one or two persons within the village who have acquired special skills in this field.

Bull to breeder ratios for both cattle and buffalo are low (1:4.3 for cattle and 1:2.0 for buffalo). A small proportion of the bulls included in these calculations may have been castrated but nevertheless, the ratio of bulls to cows would not be expected to exceed 1:5 for either cattle or buffalo. It therefore appears that there is some scope for selection and breeding within the native herds through castration of inferior bulls. Cockrill (1974) suggests a bull to breeder ratio of 1:12 for buffalo, which is significantly lower than the commonly recommended ratio for cattle but still higher than that in the present situation.

ECONOMIC ASPECTS

Income is derived from cattle and buffalo in the highlands by sales, agistment, leasing and by the use of cattle, as pack animals. The industry is based on the need for security or the need to be able to fulfil sacrificial obligations with little deliberate commercial orientation. The value placed on security and the obligation to follow traditional religious practises may be calculated, as the cost between the income that could be expected from a herd of cattle raised to produce income and the actual income derived.

Cattle and buffalo sales were usually restricted to the village locality because stock had to be walked from place to place across difficult terrain. Buyers usually came to villages to buy cattle except when a villager found himself in urgent need of money. In villages close to large markets, regular visits by lowland traders have created a reasonably stable marketing system, although the extent of this contact is very limited.

An annual cycle of sales and purchases is apparent in some villages where sales are forced by rice shortages in the late dry and wet seasons. After harvest, income derived from opium or other crops is partially invested in more stock. Lowland Thai people in many cases buy buffalo to work paddy fields at the start of the rice season and then sell them when the season has finished which creates a situation of purchase prices for the lowland farmer being higher than selling prices. This is not considered to be uneconomic however because the difference in the price is usually less than the cost of renting a buffalo for the season. Highland villages in reasonably close proximity to lowland rice paddies become involved in this system to a minor extent by buying at the end of the rice season. Natural increase in addition to the price disparity enhances the potential profitability of this enterprise.

The income generated from stock is not usually a significant part of total household income except in the cases of some large stock owners. However, Hinton (1975) notes that sales of livestock including pigs and poultry can be the largest single income producing item in a Karen village where opium is not cultivated. Stock sold to the lowlands are used for draught and meat purposes. Highland cattle tend to be smaller than lowland cattle or cattle entering Thailand from Burma, thus they are less popular for draught purposes. Those stock destined for the meat market include both male and female stock, Despite laws aimed at restricting killing to unproductive animals (Propagation and Conservation of Livestock and Beasts of Burden B.E. 2492 (1949)).

Price information can only be of a general nature as a function of the assumptions made in collating data. It must be assumed; that owners' memories are accurate, that the liveweight of the cattle and buffalo in question are typical for the ages of the animals, and that prices were uniform over the whole area of the highlands. Despite these seemingly gross assumptions, general trends in prices for cattle and buffalo are useful for comparative purposes. The prices for buffalo transactions appear to be more variable than those for buffalo. A buffalo trained to work and of good conformation can attract a significantly better price than can an untrained beast of poorer conformation at the same weight.

The prices recorded in a survey are lower than those commonly quoted by developmental agencies (Ashfaq and Kitiwan, 1976), which are commonly based upon lowland market rates. Transactions in the more remote areas tend to be at lower prices, presumably because the demand is lower due to the higher costs associated

with transporting animals to the market area. Mean prices for cattle sold in the lowlands (Chiang Mai) over the period January-April 1976 varied from approximately 4500 baht (US$ 225) for a large animal to approximately 2400 baht (US$ 120) for a small animal. For buffaloes the range was about 4350 baht (US$ 217.50) to 2400 baht (US$ 120). These prices are at least 25% higher than those recorded for highland transactions even when variations in the mature sizes of the cattle from the different regions are considered.

The variation of prices for both cattle and buffalo over twenty years indicate that the price of both cattle and buffalo has risen by an average of 23% per year. For cattle a steady rise in price over the whole period is indicated while in the case of buffaloes, the rise seems to have been largely restricted to the last six years. The rise in price from the 14 years 1956 to 1970 was only 9% compared to 31% for the six year period 1970 to 1976. This may reflect some increasing demand for buffalo in the lowland regions close to the highland regions over the last six years. In lowland regions, buffalo are generally considered to be more useful than cattle for paddy cultivation and greater price elasticity is shown in response to increased demand. Mechanical cultivation of paddy fields, while quite common in many regions of Thailand, is seldom seen in paddy fields adjacent to the highland area.

Stock placed in highland villages on agistment usually belong to lowland dwellers who do not have sufficient area to run their cattle. In exceptional cases cattle may be agisted by highland people. The proportion of villages where cattle or buffalo were involved in agistment is probably about 30%, which makes this enterprise of potential economic importance to highland people.

Income From Leasing of Working Stock

Buffalo are raised in some Akha and Lahu villages for leasing to lowland rice growers during the dry season. Usually persons renting the buffalo are lowland Thais who do not own buffalo and cannot rent elsewhere.

The choice as to whether the rental fee is to be paid in cash or rice is usually made before the buffalo is taken although the conversion rate between the two is known to both parties. Under some circumstances a percentage (usually around 15) of the rice harvest may be agreed upon by both parties. Large differences in the fees charged are evident; the two most important factors in this business are proximity to paddy rice fields and the availability of working buffalo in the area. Arrangements between the leasee and leasor vary from verbal agreements, where the buffalo owner has little recourse in the event of accidents or foul play, to written contracts.

In the highlands, cattle, horses and donkeys are employed to transport loads along narrow, winding, steep trails. In most cases, horses are the preferred species especially

among the hilltribes. Miang growers, however usually use cattle to transport their product to the nearest road if the road does not reach their village. Keen (1972) notes that miang is transported by slinging one tang on each side of pack cattle beasts which are led along mountain trails in a long cattle train.

Roy (1965) notes that a miang garden tenant often invests in oxen because they are readily available and saleable. At the time Roy wrote, a young bull could be bought for 500 baht, and after five years, be sold for twice that price while having earnt an income as a pack animal during the five years. Pack animals were said to be able to earn about 350 baht per year. Households engaged in this enterprise generally charged around 30 baht (US$ 1.25) per 100 kg transported to the nearest road served by regular motorized transport in 1980.

Movement of Livestock Into Thailand

The number of cattle and buffalo raised in Thailand when compared to the number consumed indicates that some of the stock must come from neighbouring countries. The official means of bringing stock into Thailand involves, firstly contacting the local amphoe office and supplying a description of the animal. The amphoe veterinarian must then be advised so that he can inspect the stock and vaccinate against the diseases, foot and mouth and haemorrhagic septicaemia. Customs duty of 45 baht per head or 3% of the purchase price is then payable to allow the stock to enter Thailand. Stock can stay in the region for a period of two weeks while the amphoe representative contacts the Livestock Department for formal permission to move the stock into Thailand. Unfortunate experiences of delays has encouraged the development of an illegal trade which handles most of the stock traffic into Thailand.

Some disease control is practised by persons involved in the illegal cattle and buffalo importing business; animals that are obviously sick are not brought into Thailand. If cattle are to be held for any period of time, they are kept on the Burmese side of the border and thus any sick animals are left in Burma rather than Thailand.

The main area of cattle and buffalo imports into Thailand is Mae Sod, and the principle ethnic group involved is the Karen who are often at war with the Burmese. The Karen have settled on both sides of the river between Thailand and Burma which facilitates the movement of livestock. In one village, stock are moved across at an estimated average rate of about 80 head per day, although up to 400 head per day has been observed when prices and weather conditions favour the movement of large herds. At another village in the Mae Sod area an estimated average of 300 head per day come from Burma during the dry season period. Small numbers of sheep and goats are also brought across the border at these places.

A tax of ten baht per head is charged by the Karen for the cattle leaving Burma and a tax of 45 baht is also payable to the Thai customs for cattle entering Thailand. Buyers come to inspect large herds of cattle on the Thai side of the border and purchases are made on an individual animal basis. Cattle are purchased at prices ranging from 800 to 3000 baht for cattle and 1500 to 5000 baht for buffalo. Most stock are transported out of the province soon after arrival to avoid the necessity to conform with amphoe registration. Stock are trucked to markets in Sukhothai, Lampang, Chiang Mai and Bangkok. Sukhothai is a large market for draught cattle where stock may be taken to fatten before being resold. Buffalo for draught purposes are mainly sold in Lampang province while both cattle and buffalo are sold in Chiang Mai and Bangkok. The profits accrued in this business were said to be about 20% for the Karen selling to the Indian, Chinese and Thai merchants who in turn, receive a profit of about 30%.

The second main area of stock movement into Thailand involving Shan, Kachin, Tung Su, Lahu and Chinese Haw ethnic groups is in amphoe Fang, north of Chiang Mai. An estimated number of 1000 head of cattle and buffalo were said to enter Thailand at Doi Luang, Doi Mae Na and Doi Mae Sao. A charge of about 50 baht per head for stock entering Thailand is payable to Chinese Nationalist soldiers or other groups inhabiting the border region. In two other villages involved in this trade, an estimated number of 2000 head of cattle and buffalo in 1975, 100 head in 1976 and probably less for the survey year 1977, had entered Thailand. Stock entering via amphoe Fang reach the lowlands near amphoe Chiang Dao where they are sold mainly to traders from Chiang Mai.

In the vicinity of Mae Sariang, cattle and buffalo enter Thailand through Karen and Shan villages across the Salween River. About 100 head per year,of which about 70% are buffalo, are said to enter Thailand from Burma via this route. At Mae Hong Sorn, cattle and buffalo also enter Thailand from Burma via Shan villages with the involvement of the Shan Union Army and the Chinese Nationalist Army. Stock also enter from Burma at Akha and Lahu villages in Chiang Rai province although the numbers are apparently small and the trade erratic.

A total number of more than 10,000 cattle and buffalo are probably entering northern Thailand from Burma each year. While the number must vary greatly, the well developed infrastructure for this trade allows it to act quickly in response to economic demands. The movement of cattle and buffalo into Thailand from Burma in response to the better markets of Thailand has had its corollary in the movement of stock across the Thailand-Malaysia border in response to an even better market (Maligul, 1977), although prices in Bangkok are attractive enough to attract stock from the upper half of the southern peninsula.

CHAPTER 5

Cattle Productivity

INTRODUCTION

The levels of productivity of highland cattle are low; actual levels require some definition. Research based on the measurement of girth circumference (Hoare and Mikled, 1975; Gibson, 1976) has been conducted and, since 1976 more accurate information has been obtained. Relationships between liveweight and various body parameters have been calculated from data collected elsewhere in Thailand (Rufener, 1971; Rattanaronchat, 1975; Songkprasert, 1976). Such a relationship is specific to one breed of cattle; thus it is necessary to have a predictive relationship for liveweight of highland cattle.

Low productivity of cattle may be related to either the environment or genetic limitations of the breed. One aspect of the environment is the restricted grazing time of cattle in the highlands which is associated with tradition and the rugged terrain. Grazing studies are usually conducted on cattle that have access to pasture night and day and the results of the behaviour of cattle under those conditions may therefore vary from the behaviour of cattle only allowed access to pasture during daylight. The steep terrain, sparse plant population in some areas and the mild tropical climate introduce further variations.

GROWTH CURVES OF HIGHLAND CATTLE

Prediction of Liveweight

A correlation coefficient for the relationship between liveweight and girth circumference was 0.99 while that between liveweight and height at the withers was 0.94. The quadratic relationship for liveweight against circumference is described by the equation:

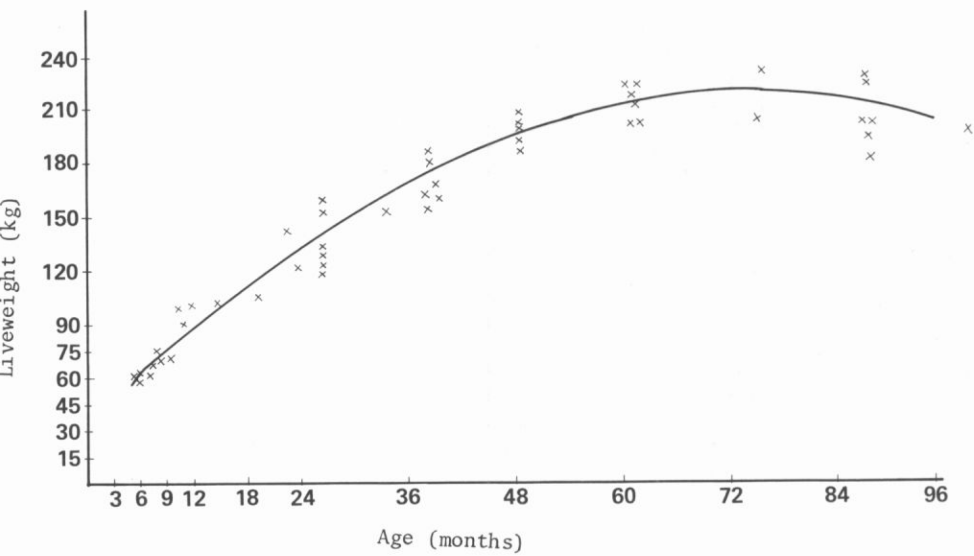
$$\text{Weight} = 0.01015969\ (\text{girth})^2 - 0.120\ (\text{girth}) - 6.45 \qquad (1)$$

The relationship between liveweight and girth circumference is a more useful predictor of liveweight than relationships including height. Physical variations within the native cattle of this region are reflected most obviously in terms of length of leg. Elsewhere in Thailand linear relationships including the additional parameter of body length (Rattanaronchant, 1975; Songkprasert, 1976), or logarithmic relationships between girth (g) and liveweight (W) (Rufener, 1971) have been determined. In each of these cases, animals were probably of a wider genetic base than those in the highlands and the relationships correspondingly less accurate.

Growth and Liveweight

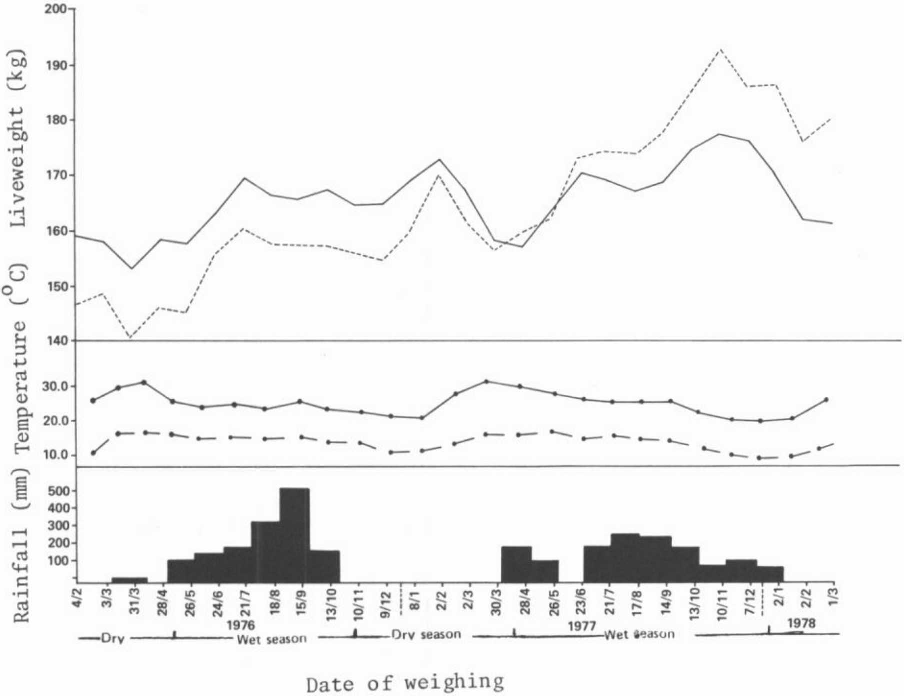
A quadratic relationship between body weight and estimated age is described by the equation (see following figure):

$$\text{Weight} = -0.3351061\ (\text{age})^2 + 5.0682\ (\text{age}) + 31.33$$



Age and weight relationship and the quadratic regression.

A mean liveweight curve for a graph of ten animals is presented as the following figure. The mean liveweight of this herd did not increase over the two year investigation period because of the effects of calving. A curve of the mean liveweights of non reproducing animals is also included in the figure which shows a liveweight gain of 32.5 kg over 25 months.



Mean liveweights of a mixed herd of ten cattle (—) and two non-reproductive cattle (--) grazing native highland pasture. Data for mean rainfall and mean maximum (•—) and minimum (– •) temperatures is also presented.

Liveweight gains occur in the transition period between the dry and wet seasons and not in the cool dry season and liveweight losses occur about the month of August. This relationship provides an estimated growth curve for highland cows indicating a mature liveweight of 223 kg at an age of 6.3 years. Changes within years suggest that

the first peak in liveweight gain occurs at the end of the hot-dry season about three weeks after the native pastures are burned by the annual wildfires. Liveweight losses during the month of August may be related to the higher rainfall intensity common to this month which tends to reduce grazing times. Similarly, liveweight gains in the cool-dry season coincide with longer grazing times. Productivity of cattle in the highlands therefore appears to be limited by restricted grazing times. Research conducted in Louisiana, Fiji and Trinidad suggests that high levels of productivity of cattle in the tropics cannot be obtained without access to good quality pasture through the night when temperatures are more conducive to grazing (Webster and Wilson, 1971).

Reproduction

The mean birth weight of calves born to a highland cattle herd site was recorded to be 13.8 kg and the mean rate of mortality of these calves before six months of age was 21.4 percent. The mean birth weight of those calves that did not survive until six months of age (11.9 kg) was lower than that of calves that survived (14.3 kg). No calves with birth weights below 10.0 kg survived although there did not appear to be any relationship between the month of birth and mortality of calves. Calf growth rates to six months of age averaged 291 g day^{-1} with a range from 90 to 360 g day^{-1}.

Conception of cows in the herd occurred mainly between the months of August and November (59.1%), the last period of the wet season.

Birth weights and preweaning growth rates of highland cattle are lower than those recorded for cattle in the lowlands. Chantalakhana et al. (1978b) recorded a mean birth weight of 15.3 kg and a preweaning growth rate of 350 g day^{-1} while Rufener (1971) recorded a preweaning growth rate of 380 g day^{-1} at the end of the wet season. A higher incidence of conceptions in the late wet season may be related to the higher quality diet consumed by cows over the preceding months of the wet season. Estimated calving percentages of highland cattle are similar to those recorded for lowland cattle of 78 (Prucsasri, 1976) to 80 (Chantalakhana et al., 1978b) while the estimated weaning percentage is lower than those for the lowland cattle which were 69 (Chantalakhana et al., 1978b) to 75 (Prucsasri, 1976). In general, reproductive parameters appear relatively high compared to liveweight gains which suggests some adaptation to the environment of the highlands where selection pressures may favour numbers of cattle rather than high levels of individual animal productivity.

Grazing Time

The limits placed on grazing time by the environment may reduce the productivity of cattle. Mean incidences of grazing at eleven intervals throughout the day over a one year period are presented as monthly means in the following table.

The overall mean figures indicate that grazing is at its lowest incidence at 1230 hours and at its greatest at 0845 and 1615 hours. The least time is spent grazing during the months of January, February, March and April, while the most time is spent in the month of December.

The mean percentage of cattle grazing at each observation time for each month

Month	Time of day											Mean
	0845	0930	1015	1100	1145	1230	1315	1400	1445	1530	1615	
Apr	100	86	72	69	74	58	56	44	62	51	73	67.7
May	100	100	78	78	87	76	70	65	76	85	91	82.4
Jun	100	100	81	73	27	46	61	73	89	100	100	77.3
Jul	100	99	93	77	53	50	69	86	84	86	96	81.2
Aug	100	96	100	55	26	63	70	81	79	97	89	77.8
Sep	100	94	93	73	57	41	47	77	83	90	96	77.4
Oct	100	100	100	100	81	38	59	71	73	97	100	83.6
Nov	100	95	95	100	71	51	79	86	88	99	100	87.6
Dec	100	91	91	100	64	64	100	100	100	100	100	91.8
Jan	100	85	58	52	50	11	31	57	52	54	87	57.5
Feb	100	100	89	40	34	4	29	69	70	92	100	66.1
Mar	100	100	100	52	52	22	80	80	60	70	100	74.2
MEAN	100	95.5	87.5	75.8	56.3	43.7	62.6	73.8	76.3	85.1	94.3	

The mean incidence of resting is greatest at 1230 hours and least at 0845 hours. Resting while standing is more commonly observed in the early morning and late afternoon while the trend is reversed around midday. Peak incidence of resting occurs during the periods June-September and January-February, and minimum incidence during November and December. Little ruminating activity was recorded during the daytime. In the instances when it is observed it begins during the late morning. Cattle tend to ruminate to a greater extent during the night while they are in the yards.

The diurnal pattern of decreasing followed by increasing grazing activity probably represents an adaptation to restricted grazing periods; cattle with access to pasture both night and day tend to graze more intensively immediately before dawn, mid-morning, early afternoon and near sunset (Hafez and Bouissour, 1975). Daily grazing times in the highlands range from 5.2 to 7.3 hours which does not vary greatly

from the four to nine hours recorded by Hafez and Bouissour (1975) to be normal for cattle with unrestricted access to pasture. However, they also note that up to 15 hours per day may be required when pasture availability is low. Lower grazing times during the dry season reflect low quality of pasture at that time of the year. A concurrent increase in the incidence of rumination in the daytime supports this contention because feed of lower quality requires longer rumination times.

The grazing patterns of cattle in the highlands are not correlated with either the incidence of rainfall or variations in temperature. High temperatures may cause decreased feed intake although the temperatures of the highlands and the generally low relative humidity never exceeded those suggested by McDowell (1972) to be the limit above which grazing time reduces markedly.

The incidence of resting varies inversely with that of grazing, with a peak at 1230 hours. Dwyer (1961) recorded an average of 6.66 hours resting time per day. The mean figure for the highlands is one hour of 16% of the grazing day. Much of the resting time usually spent during daylight hours appears to be transferred to the night in this system representing some adaptation to the restricted access to grazing.

A preference for valley areas during the dry season suggests that availability of such areas may be a determinant of the stocking potential of a given area in the highlands. An average stocking pressure of 15 hectares per beast was calculated for one highland herd but the actual stocking pressure in valley areas may be as high as one beast per hectare during the late dry season.

The low productivity of cattle in the highlands, particularly with respect to liveweight gains is related to pasture availability and nutritional quality under the constraints of restricted access to grazing. Adaptation of highland cattle to the environment is evident and it is therefore possible that differences between highland and lowland cattle may have some genetic base.

CHAPTER 6

Supplementary Feeding

INTRODUCTION

Native cattle in many regions of the tropics have evolved under conditions of poor nutrition to produce hardy breeds that may be unable to respond to diets of high nutritional quality (McDowell, 1972). Supplementation with additional nutrients during the dry season and means of their administration are important to the understanding of ways of increasing productivity. Supplements containing specific nutrients are utilized to reduce seasonal liveweight losses of cattle at pasture in other regions (Winks et al., 1977a). Improved pasture based on legumes can also provide a diet of higher nitrogen and energy content than native pasture (Norman and Begg, 1973) and are also important as a supplement to native pastures.

MAXIMUM GROWTH POTENTIAL

Young highland cattle fed concentrates at between 1.5 and 3.2 kg per day showed a mean liveweight increase of 188 kg compared to 95 kg for the group not receiving the concentrate. The highest sustained average daily liveweight gain (to 278 kg) of cattle receiving concentrates was 343 g day^{-1}. Calves born to this group grew at a mean rate of 535 g day^{-1}.

These high liveweight gains suggest that native cattle are genetically capable of making a large liveweight response when fed a diet of high nutritional value. While liveweight gains cannot be classified as very high in absolute terms, the large response recorded indicates that nutrition is the principal factor limiting cattle productivity in the highlands. The ability of highland cattle to respond to improved nutrition suggests that development of the industry should be based on the existing breed.

SUPPLEMENTARY FEEDING IN THE DRY SEASON

Cattle allowed access to improved pasture for half of each day or supplemented with urea and molasses gain more liveweight during the hot dry season although improvements are small. Responses are probably related to increased intake of energy or nitrogen from either the molasses and urea respectively or from the improved pasture. Roller lickers to provide urea/molasses supplements are limited in their application in their field application due to inherent problems of ammonia volatilization and limited accessibility to extensive grazing conditions in rugged topography such as the highlands. High levels of energy supplementation is not the sole contributant to responses. Thus while there is a large potential for increasing the productivity of native cattle in the highlands through improved nutrition, the increased liveweight gains produced by supplementary feeding of molasses, urea and mineral supplements or half day access to improved pastures are not as high as those recorded for cattle consuming concentrates.

SUPPLEMENTATION WITH SODIUM AND PHOSPHORUS

Liveweight gains of cattle receiving a sodium and phosphorus drench were significantly higher over the late dry and wet season in a four year experiment. Supplemented cows produced significantly more calves during the experiment of which the mortality rate was significantly lower than that of unsupplemented animals.

The mean faecal nitrogen, phosphorus and sodium analyses for both supplemented and unsupplemented animals are presented in the following table. Faecal sodium values were significantly higher for supplemented animals while there were no differences for nitrogen and phosphorus.

Mean faecal nitrogen, phosphorus and sodium analyses ($g\ kg\ DM^{-1}$) for supplemented and unsupplemented cattle.

Treatment	Date and Analyses														
	3/3/77			21/7/77			1/3/78			4/5/78			24/5/78		
	N	P		N	P		N	P	Na	N	P		N	P	Na
Supplemented	26.8	4.6		17.2	3.8		7.8	4.3	1.1**	18.3	6.2		22.5	6.8	1.9**
Unsupplemented	14.1	5.0		18.2	4.6		7.7	5.2	0.6	19.7	6.4		24.8	7.3	0.6
	16/8/78			10/10/78			14/2/79			24/5/79			24/8/79		
	N	P	Na	N	P	Na	N	P	Na	N	P	Na	N	P	Na
Supplemented	16.3	5.9	1.3**	15.7	4.4	1.4**	12.3	6.3	3.4**	15.2	5.1	0.8*	6.8	5.4	3.5*
Unsupplemented	17.9	5.2	0.7	18.2	4.1	0.6	14.5	5.9	0.7	17.3	5.4	0.4	6.7	4.9	1.2

Significant differences between means at any one date are signified by *($P<0.05$), **($P<0.01$) and *** ($P<0.001$).

There were significant differences between the two groups in the ratio of sodium to potassium in saliva and rumen fluid, while there were no significant differences ($P > 0.05$) between the supplemented and unsupplemented cattle in terms of phosphorus and calcium contents in saliva and rumen fluid. Supplemented and the unsupplemented animals did not vary in the concentration of phosphorus in fresh rib-bone and fat free bone, the density of phosphorus in the bone or specific gravity.

Sodium Status of Cattle

Liveweight and reproductive rate responses are related to increased sodium status. Where sodium deficiency occurs, increased intestinal absorption of sodium and consequent reduced faecal sodium occurs while plasma sodium levels vary only slightly and salivary sodium is replaced by potassium (Denton, 1956). Thus the lack of variation between the serum sodium levels of the two groups in this experiment is not at variance with the significant differences in salivary and rumen sodium to potassium ratios and faecal sodium contents. Bott *et al* (1964) recorded salivary sodium to potassium ratios of 8 to 30:1 for sodium sufficient and 0.3 to 5:1 for sodium deficient cattle. Reichel *et al* (1973) believes the ratios between 16 and 11 indicate suboptimal sodium, and ratios below 11 indicate sodium deficiency. Sodium to potassium ratios were significantly different for the highland cattle and the absolute values for the supplemented group ranged from 7.7 to 15.4 which according to the scale of Reichel *et al* (1973) represents a suboptimal sodium status although it appears adequate from the results of Bott *et al*. (1964). Absolute sodium contents of the saliva of unsupplemented animals approached or were below the suggested critical level of 100 mg l^{-1} (Alexander, 1973) at each sampling date. The significant differences in rumen fluid sodium and potassium contents and sodium to potassium ratios support these results.

Phosphorus Status of Cattle

Becker *et al*. (1965) have shown that the orthophosphate form of phosphorus as administered in this experiment is more readily utilized by cattle than the metaphosphate form. Responses to phosphorus are therefore expected if cattle are simply phosphate deficient. Faecal phosphorus is recognized to be a superior indicator of the phosphorus status of ruminants (Moir, 1966a) than is serum phosphate because serum phosphate is affected by homeostatic mechanisms, recent diet and the state of excitement (Little, 1972b), whereas faecal phosphorus contains all surplus dietary phosphorus (Townes *et al*., 1978). No differences were recorded between the two groups in terms of either serum of faecal phosphorus for highland cattle. Cohen (1978) notes that there is no specific data relating to the salivary phosphorus levels although he recorded values of 15 to 18.3 mg P 100 ml^{-1} in rumen fluid under phosphorus deficient conditions; this is much lower than the mean value recorded for highland cattle of about 55 mg P 100 ml^{-1}.

Rib bone samples possibly represent the most accurate indicator of phosphorus status in ruminants. Little and Minson (1977) recorded bone phosphorus contents of 174.3 mg cc^{-1}, 9.55% in fresh bone and 11.66% in dry fat free bone and a mean specific gravity of 1.83 for cattle that had grazed pastures fertilized with phosphorus. Differences between these figures and those determined for highland cattle appear to be related to a higher fat content in the bone; the percentage of phosphorus by weight in fat free bone was higher than that recorded by Little and Minson (1977) while the other parameters were incomparable due to different fat contents in the bone. The lack of any difference between the groups, even when only non-lactating cows were considered, indicates that additional dietary phosphorus was of little consequence. Phosphorus is not limiting the productivity of cattle grazing native pastures in the highlands and this is supported by the apparently adequate levels of phosphorus in the native species grazed by cattle.

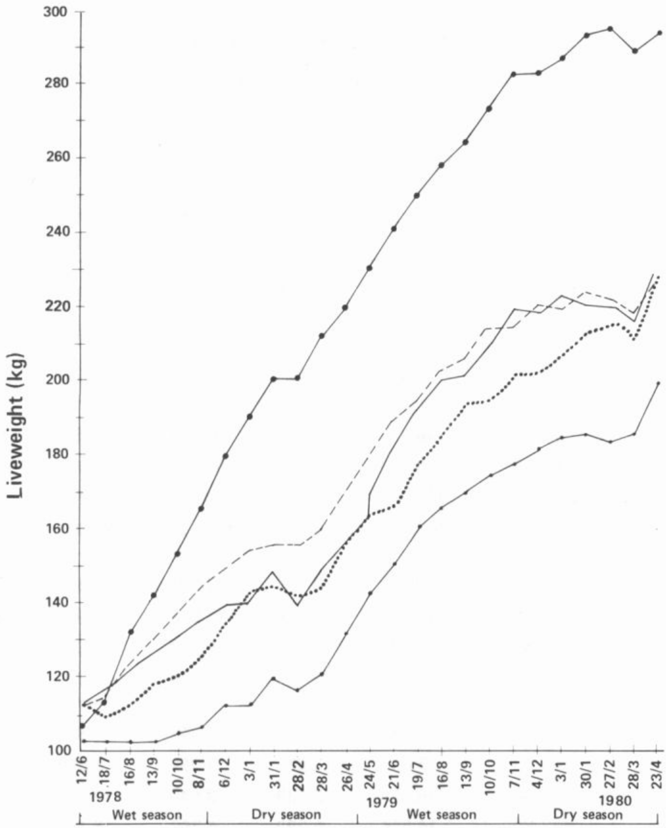
ALTERNATIVE SUPPLEMENTATION STRATEGIES

Liveweight

An experiment comparing seasonal supplements of sodium, urea and phosphorus, improved pasture as a supplement and concentrates provided the result that sodium and feed intake deficiencies limit production. Cattle receiving dry season supplementation failed to show any higher liveweight gains during any one seasonal period. The cattle receiving the wet season supplements and the improved pasture supplement showed significantly higher liveweight gains than the unsupplemented group during the wet seasons and significantly lower liveweight gains during the dry season. Cattle receiving concentrates showed significantly higher liveweight gains than all other groups. Trace element supplementation provided no response in any treatment. Mean liveweights of animals in each main treatment are presented in the following figure.

Cattle receiving concentrates exhibited the highest liveweight gains except during the last seasonal period when they approached mature liveweight. Cattle receiving the three different supplementation treatments all showed improved liveweight gains that were a mean of 31 percent of the improvement that is genetically possible (when concentrates were fed). As the major responses appear during the first year of supplementation this introduces an alternative management strategy in the allocation of supplements within a herd.

In the dry season, liveweight responses to supplementation were associated with increased sodium status and increased faecal output. In the wet season, sodium status was also increased by supplementation leading to feed intake. However, for improved pasture supplements the response was associated with increased feed intake alone.



Liveweights of cattle receiving concentrates (●—●) dry season supplement (....), wet season supplement (——), improved pasture supplement (----), or no nutritional supplement (.—.).

Composition of Saliva

The mean concentrations of sodium, potassium, phosphorus and calcium in saliva are presented in the following table. Salivary sodium to potassium ratios of cattle receiving the seasonal supplement were significantly higher than those cattle not receiving their seasonal supplement, those cattle receiving the improved pasture supplement and those cattle not receiving any other supplement on all occasions. No general trends for differences in salivary phosphorus or calcium concentrations were evident and no significant differences between trace element treatments were recorded.

Saliva contents of sodium, potassium, phosphorus and calcium and sodium to potassium ratios in the five main treatments for four samplings.

Analysis	Date	Treatment				
		(i)	(ii)	(iii)	(iv)	(v)
Urea (mg%)	20/3/79	2.12^{a}	2.87^{b}	3.93^{a}	1.97^{b}	3.05^{a}
	29/4/79	2.05^{ab}	1.88^{b}	2.53^{a}	1.90^{b}	1.87^{b}
	31/1/80	3.18^{a}	1.52^{b}	1.93^{ab}	4.01^{a}	1.44^{b}
Sodium (meql^{-1})	20/3/79	130.7^{a}	100.0^{bc}	86.6^{c}	118.6^{ab}	85.1^{c}
	29/4/79	74.5^{ab}	95.2^{ab}	66.8^{b}	92.0^{ab}	101.0^{a}
	31/1/80	128.6^{a}	92.2^{b}	83.3^{b}	87.5^{b}	86.7^{a}
	26/3/80	163.5^{ab}	141.3^{b}	117.17^{c}	165.0^{a}	143.7^{b}
Potassium (meq l^{-1})	20/3/79	8.37^{b}	38.83^{a}	37.50^{a}	10.37^{b}	47.08^{a}
	29/4/79	24.76^{b}	6.88^{d}	39.37^{a}	12.98^{c}	36.98^{a}
	31/1/80	8.70^{b}	45.67^{b}	37.92^{b}	7.50^{a}	49.73^{b}
	26/3/80	11.75^{c}	43.5^{ab}	50.75^{a}	10.30^{c}	39.17^{b}
Sodium: potassium	20/3/79	18.08^{a}	3.73^{c}	5.34^{c}	12.82^{b}	2.49^{c}
	29/4/79	3.83^{c}	13.8^{a}	1.95^{c}	8.50^{b}	3.22^{c}
	31/1/80	16.07^{a}	2.53^{b}	2.64^{b}	12.16^{a}	2.32^{b}
	26/3/80	14.51^{a}	5.29^{b}	4.28^{b}	16.16^{a}	5.23^{b}
Phosphorus (mg%)	20/3/79	41.68^{a}	52.67^{a}	44.77^{a}	40.82^{a}	50.47^{a}
	29/4/79	26.07^{b}	33.88^{ab}	40.53^{ab}	25.87^{b}	47.30^{a}
	31/1/80	34.8^{ab}	51.03^{a}	37.85^{b}	18.83^{b}	47.32^{ab}
	16/3/80	54.25^{a}	48.98^{a}	49.17^{a}	45.0^{a}	47.32^{ab}
Calcium (mg%)	20/3/79	2.22^{b}	2.08^{b}	3.42^{a}	2.32^{b}	2.75^{ab}
	29/4/79	2.98^{a}	1.32^{b}	2.75^{a}	2.45^{a}	1.90^{ab}
	31/1/80	2.84^{a}	2.73^{a}	3.01^{a}	3.41^{a}	2.81^{a}
	26/3/80	4.23^{a}	4.98^{a}	4.85^{a}	4.37^{a}	4.28^{a}

Means followed by the same superscript within a row do not differ significantly ($P > 0.05$)

(i) dry season supplement (ii) wet season supplement (iii) improved pasture supplement (iv) concentrates (v) no supplement.

Salivary sodium levels were raised above the critical level of 100 $meql^{-1}$ (Alexander, 1973) in those treatments of seasonal supplementation and concentrate feeding. Salivary sodium to potassium ratios were within or very close to the range of the sodium deficient animals (0.3 to 5:1) for those animals seasonally unsupplemented, those receiving the improved pasture supplement, and those in the control group while those of animals receiving concentrates or seasonal supplementation were within the range for sodium sufficient animals of 8 to 30:1 (Bott et al., 1964).

Composition of Rumen Fluid

Levels of ammonia-nitrogen, sodium, potassium, phosphorus, calcium and sodium to potassium ratios for rumen fluid (see following table) indicate that the rumen fluid ammonia-nitrogen levels of cattle receiving the concentrate ration were significantly higher than those of cattle in all of the other groups on every occasion. No other trends in rumen fluid ammonia-nitrogen were evident. Sodium contents were generally significantly higher in the groups receiving the seasonal supplement and the concentrate ration. Sodium to potassium ratios of the group receiving the seasonal supplement at the time of sampling were significantly higher than the ratios from the seasonally unsupplemented, improved pasture and the control groups.

Critical levels of sodium or sodium to potassium ratios in rumen fluid have not been determined. Murphy et al. (1970) have shown that sodium to potassium ratios in the rumen fluid of cattle under conditions of increasing sodium deficiency can decrease from 8.9 to less that 2.0:1. Ratios as low as 1.1:1 were recorded for unsupplemented animals in the highlands while ratios for animals receiving the seasonal supplement ranged from 3.0 to 9.9:1.

Composition of Faeces

Faecal nitrogen, sodium and phosphorus analyses are presented in the following table. The faecal nitrogen levels of cattle receiving concentrates were the highest at each sampling date and generally higher in the group receiving the seasonal supplement than for the unsupplemented groups. Faecal sodium levels were highest in the seasonally supplemented and the concentrate groups and that of the cattle receiving the improved pasture supplement generally did not vary significantly from that of the control group. Faecal phosphorus levels tended to be higher in the concentrate and seasonally supplemented groups.

Rumen fluid contents of ammonia-nitrogen, sodium, potassium, phosphorus and calcium and sodium to potassium ratios for the five main treatments for four sampling dates.

Analysis	Date	Treatment				
		(i)	(ii)	(iii)	(iv)	(v)
NH_3-N (mg 100 ml^{-1})	30/1/79	4.24^b	4.16^b	4.72^b	7.81^a	4.09^b
	31/1/80	2.33^c	4.23^c	6.12^b	8.05^a	6.64^b
	26/3/80	5.80^b	4.19^b	4.34^b	9.26^a	5.71^b
Sodium (meq l^{-1})	30/1/79	81.0^a	64.7^{ab}	57.3^{ab}	80.31^a	50.2^b
	29/4/79	78.8^a	$87/7^a$	82.7^a	92.8^a	81.2^a
	31/1/80	88.8^a	74.3^b	80.0^b	113.0^a	78.7^b
	26/3/80	91.0^a	77.3^b	71.0^b	87.7^a	71.5^b
Potassium (meq l^{-1})	30/1/79	29.0^{bc}	38.2^{ab}	44.5^{ab}	23.7^c	49.7^a
	29/4/79	30.1^a	13.7^b	20.2^{ab}	13.3^b	24.4^a
	31/1/80	23.7^a	45.4^b	53.4^b	28.1^a	56.2^b
	26/3/80	29.8^b	52.0^a	45.7^{ab}	39.0^c	52.3^a
Sodium: potassium	30/1/79	3.01^a	1.92^b	1.57^b	3.58^a	1.07^b
	29/4/79	2.20^b	9.85^a	4.65^b	8.89^a	3.82^b
	31/1/80	4.18^a	1.68^b	1.55^b	4.04^a	1.49^b
	26/3/80	3.13^a	1.74^c	1.65^c	2.23^b	1.48^c
Phosphorus (mg%)	30/1/79	23.2^b	19.9^b	24.3^b	30.7^a	20.7^b
	29/4/79	45.7^a	25.1^c	41.2^a	38.0^{ab}	30.1^{bc}
	31/1/80	14.9^a	18.4^b	20.7^b	33.2^a	28.7^{ab}
	26/3/80	23.8^a	26.7^a	26.0^a	25.3^a	31.2^a
Calcium (mg%)	30/1/79	2.4^b	3.5^a	1.3^b	2.7^b	2.1^b
	29/4/79	5.2^a	3.9^a	3.5^a	2.8^a	4.2^a
	31/1/80	6.4^a	6.6^a	6.4^a	6.3^a	8.6^a
	26/3/80	4.8^b	5.2^{ab}	5.8^a	4.1^c	5.1^{ab}

Means followed by the same superscript within a row do not differ significantly ($P > 0.05$).

(i) dry season supplement (ii) wet season supplement (iii) improved pasture supplement (iv) concentrate (v) no supplement.

Mean faecal nitrogen, sodium and phosphorus levels for the main treatments at ten sampling dates.

Analysis	Date	Treatment				
		(i)	(ii)	(iii)	(iv)	(v)
Nitrogen ($g\ kg\ DM^{-1}$)	16/8/78	1.58^{b}	2.06^{ab}	1.82^{b}	2.61^{a}	2.03^{b}
	10/10/78	1.76^{b}	1.82^{b}	1.84^{b}	2.54^{a}	1.91^{b}
	8/11/78	1.75^{b}	1.78^{b}	1.75^{b}	2.20^{a}	1.86^{b}
	6/12/78	1.60^{b}	1.74^{b}	1.88^{b}	2.29^{a}	1.79^{b}
	31/1/79	1.63^{b}	1.68^{b}	1.75^{b}	2.40^{a}	1.82^{b}
	20/3/79	2.69^{a}	2.80^{a}	2.16^{a}	3.00^{a}	2.52^{a}
	24/5/79	1.47^{c}	1.83^{ab}	1.72^{bc}	2.13^{a}	1.91^{ab}
	1/9/79	1.56^{bc}	1.40^{c}	1.65^{ab}	1.98^{a}	1.85^{a}
	30/1/80	1.40^{b}	1.40^{b}	1.40^{b}	2.10^{a}	1.53^{b}
	26/3/80	1.5^{b}	1.72^{a}	1.22^{c}	1.92^{a}	1.56^{b}
Sodium ($g\ kg\ DM^{-1}$)	16/8/78	0.09^{a}	0.46^{a}	0.14^{c}	0.20^{b}	0.06^{b}
	10/10/78	0.08^{b}	0.21^{a}	0.04^{b}	0.26^{a}	0.05^{b}
	8/11/78	0.04^{c}	0.34^{a}	0.03^{c}	0.20^{b}	0.01^{c}
	6/12/78	0.70^{a}	0.03^{c}	0.02^{c}	0.17	0.02^{c}
	31/1/79	0.43^{a}	0.03^{c}	0.03^{c}	0.25^{b}	0.02^{c}
	20/3/79	0.63^{a}	0.09^{c}	0.05^{c}	0.37^{ab}	0.07^{c}
	24/5/79	0.06^{c}	0.14^{b}	0.03^{c}	0.20^{a}	0.04^{c}
	1/9/79	0.01^{b}	0.20^{a}	0.03^{b}	0.34^{a}	0.02^{b}
	30/1/80	0.15^{b}	0.02^{c}	0.02^{c}	0.23^{a}	0.04^{c}
	26/3/80	0.30^{a}	0.05^{b}	0.05^{b}	0.04^{a}	0.04^{b}
Phosphorus ($g\ kg\ DM^{-1}$)	16/8/78	0.55^{b}	1.12^{a}	0.58^{b}	0.66^{b}	0.55^{b}
	10/10/78	0.40^{b}	0.63^{a}	0.37^{b}	0.61^{a}	0.41^{b}
	8/11/78	0.50^{c}	1.20^{a}	0.47^{c}	0.79^{b}	0.60^{c}
	6/12/78	0.81^{a}	0.49^{b}	0.49^{b}	0.77^{a}	0.57^{b}
	31/1/79	0.44^{b}	0.32^{c}	0.42^{bc}	0.83^{a}	0.37^{bc}
	20/3/79	0.73^{b}	0.76^{b}	0.64^{b}	1.68^{a}	0.70^{b}
	24/5/79	0.50^{c}	0.59^{b}	0.50^{c}	0.73^{a}	0.51^{bc}
	1/9/79	0.47^{b}	0.45^{b}	0.43^{b}	0.83^{a}	0.47^{b}
	30/1/79	0.42^{b}	0.27^{c}	0.35^{bc}	0.71^{a}	0.29^{c}
	26/3/80	0.64^{b}	0.65^{b}	0.51^{b}	0.96^{a}	0.60^{b}

(i) dry season supplement (ii) wet season supplement (iii) improved pasture supplement (iv) concentrates (v) no supplement.

Feed Intake

Feed intake can be estimated from estimated faecal outputs using a Cr_2O_3 technique. Estimated values for feed intake as a proportion of liveweight for four season periods are presented in the following table. The digestibilities of improved pastures do not vary greatly from those of native pasture and it is assumed that the total digestibilities of the ration of cattle receiving the improved pasture supplement were the same as those recorded for native pasture. Feed intakes as a percentage of liveweight were lowest in September and highest in January.

Estimated daily feed intake (kg) as a percentage of liveweight.

Date	Treatment			
	(i)	(ii)	(iii)	(v)
June 1979		2.0	1.9	2.3
September 1979		1.4	1.4	1.3
January 1980	2.9		2.9	2.5
March 1980	1.5		1.6	1.5

(i) dry season mineral supplement (ii) wet season mineral supplement

(iii) improved pasture supplement (v) no supplement.

The liveweight response of the cattle that received the improved pasture supplement was apparently not related to the increased protein intake, as indicated by similar levels of serum urea, rumen fluid ammonia-nitrogen and faecal nitrogen in supplemented and unsupplemented cattle. The significantly higher levels of faecal output in three of the four seasonal periods suggests that the liveweight response was related to increased feed intake. The low sodium content of the improved pasture supplement and the lack of any significant differences in the sodium levels of the various samples collected, precluded the explanation of a sodium response as suggested for the seasonally supplemented groups.

Increased feed intakes are a consequence of supplementation during the late-wet, cool-dry and hot-dry seasons. This may be related to increases in the sodium status of cattle receiving the seasonal supplements; Seth et al. (1973) have recorded a decrease in feed intake under conditions of sodium deficiency. The lower magnitude of the faecal outputs of all three groups during the mid-wet season suggests the absence of any response rather than the absence of any deficiency at that time.

Comparison between the estimated feed intakes and that calculated to be necessary for animals to achieve maintenance on diets of different digestibilities indicate that cattle were probably consuming a diet insufficient for maintenance during the late wet season (September) and the hot dry season (March). Supplements increased feed intake but levels still appeared to be below optimum (3%) for supplemented cattle at all dates except the cool dry season (January), probably because of their higher liveweights.

These estimates are substantiated by liveweight changes with variations being attributable to the additional feed intake requirements for walking up the steep slopes in the highlands (see footnote).

Nitrogen

Administration of urea in a single dose effectively raises rumen fluid ammonia-nitrogen levels above those of unsupplemented animals for at least 4.5 hours (see following figure). If the figure of 5.0 mg NH_3-N 100 ml^{-1} is accepted as the limit below which microbial fermentation is inhibited (Satter and Roffler, 1975), then the period of benefit from the supplements can be more readily compared. Urea administration is of benefit after 8.3 hours from single or split administrations.

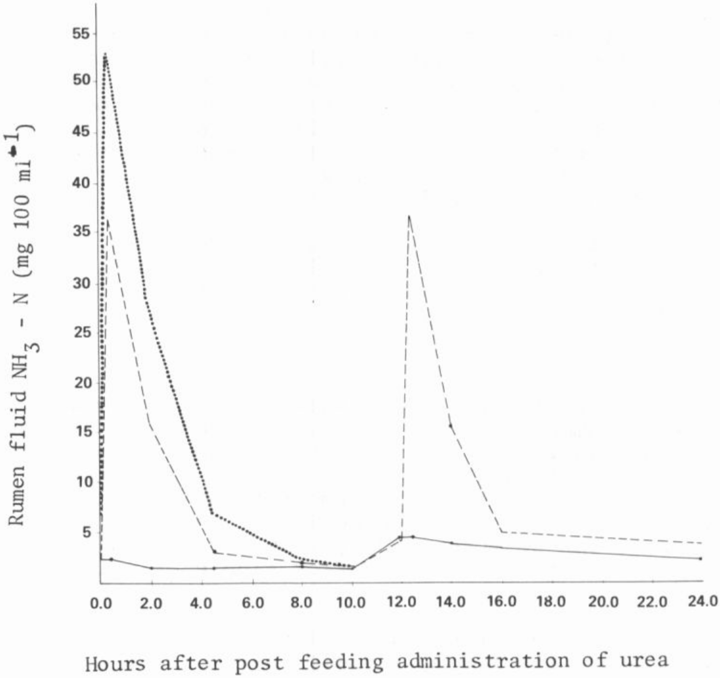
Perez *et al*. (1967) recorded a rise of rumen-fluid ammonia-nitrogen above the 5.0 mg 100 ml^{-1} level for a period of 12.0 hours from the administration of a single dose of 20 g of urea to sheep that had not received feed or water before and after drenching. The longer period for which ammonia levels were raised in that study than for highland cattle may have been related to the low levels of ingesta in the digestive tract and a consequently slower rate of movement of rumen contents out of the rumen.

Footnote:

Assume: (i) Energy cost of walking on a horizontal surface is 79 kcal 100 kg LW^{-1} $mile^{-1}$ (ARC, 1965); (ii) Energy cost of climbing is 207 kcal 100 kg^{-1} 1000 ft^{-1} (ARC, 1965); (iii) Energy cost of descending similar to that of walking on a horizontal surface.

Source of energy expenditure: (i) Walking to grazing area; 2 miles horizontally, 500 ft vertically; (ii) At grazing area; 1 mile horizontally, 100 ft vertically; (iii) Returning to cattle yards; 2 miles horizontally, 200 ft vertically.

Therefore: Total energy cost per day for a 200 kg beast is 1.12 Mcal day^{-1}. Maintenance requirements of 200 kg beast is 8.6 Mcal day^{-1} (ARC, 1965). Energy intake requirement (assuming a dry matter dibestibility of 60% is $\frac{9.72}{0.82 \times 0.60}$ Mcal day^{-1}. Feed intake requirement (assuming an energy content of roughages of 4.0 Mcal kg^{-1}) is $\frac{9.72}{0.82 \times 0.60 \times 4}$ kg day^{-1}.
Therefore: total feed intake requirement of a 200 kg beast in the highlands is <u>4.94 kd day^{-1}</u>. The energy cost of walking and climbing increases the feed intake requirement <u>by 13.3 per cent</u>.



Rumen fluid ammonia-nitrogen levels from Experiment 1 after one dose of urea (·····), two doses of urea (---) and no dosage (—).

The liveweight response was not related to any differences in metabolic parameters of nitrogen or phosphorus status between supplemented and unsupplemented cattle but was related to sodium status as discussed above. However, rumen fluid ammonia-nitrogen levels indicate that nitrogen is insufficient for microbial growth (Satter and Roffler, 1975) and, as mentioned above, administration of urea provides a transitory rise (eight hours) in ammonia levels in the rumen. Samples collected from oesophageally fistulated cattle indicated high nitrogen contents of ingested herbage during all seasonal periods and this is a better indicator than rumen fluid ammonia levels of the liklihood of a response to additional nitrogen (urea) occurring. It is of interest to note that responses to supplementary urea have been recorded quite infrequently in grazing situations as compared to pen feeding experiments (Loosli and McDonald, 1968; Leng et al., 1973).

Phosphorus and Trace Elements

Tendencies to higher levels of faecal phosphorus in cattle receiving the supplements are considered to be related to increased phosphorus intake rather than increased phosphorus status as surplus dietary phosphorus is excreted mainly in the faeces (Townes et al., 1978).

The lack of any liveweight response to the trace element supplement and significant differences between the two groups with regard to all of the analyses conducted, indicates that other trace elements were probably not a limiting factor. The trace element mixture contained small amounts of sodium (0.45 g hd^{-1} day^{-1}) compared with much higher levels provided by seasonal supplements (7.30 g hd^{-1} day^{-1}) which were in the range of recommended figures for different classes of livestock of 3.4 g hd^{-1} day^{-1} for weaner calves (Morris and Murphy, 1972) to 21.3 g hd^{-1} day^{-1} for lactating dairy cows (N.R.C., 1971).

Cattle productivity is limited by a feed intake and a sodium deficiency in the highlands. Restricted grazing time limits feed intake and low sodium contents in the species consumed limits cattle productivity. Provision of additional feed increased intakes as well as total sodium intake although it is likely that sodium intake was still suboptimal. Provision of supplementary sodium increases feed intake although not to the same degree as does the provision of additional feed yet leads to a similar increase in liveweight gain. An additional increase in liveweight gain may therefore be possible from a combination of both sodium supplementation and additional feed although the response would not be expected to be additive.

CHAPTER 7

Improved Pastures

INTRODUCTION

Improved pastures can increase cattle productivity by providing a more nutritious diet than that provided by native tropical pastures and carrying higher numbers of cattle per unit area (Norman and Begg, 1973).

Extensive pasture evaluation research has indicated the suitability of the pasture species: *Desmodium intortum*, *Stylosanthes guianensis*, *Macrotyloma axillare*, *Trifolium repens*, *Setaria anceps* and *Brachiaria decumbens* to the highlands (Gibson and Andrews, 1978). Gibson (1978) has demonstrated that improved highland pastures based on *Desmodium intortum* can sustain stocking rates in excess of one beast per hectare. Mineral deficiencies limit the productivity of cattle grazing native pastures and may similarly be of importance in cattle grazing improved pastures. Grazing pressure is related to weed invasion in native pastures and may be of similar importance to improved pastures particularly at the very much higher grazing pressures that are necessary to obtain economic utilization of continuously grazed improved pastures; high grazing pressures are also conducive to spread of disease, particularly internal parasites.

COMPARISON OF NATIVE AND IMPROVED PASTURES

Improved pastures grazed continuously at about one beast per hectare showed a gradual decline in both legume and grass yields. Weeds (85% *Eupatorium adenophorum*) were a severe problem and dry matter yields of the improved pasture on offer were lowest during the late dry season (February to April). The average nitrogen content of legume (2.1%) was almost double that of grass (1.1%) but average phosphorus contents of legume (0.19%) and grass (0.17%) were similar. Nitrogen and phosphorus contents were also lowest in February and March and highest in the period from May to September (wet season).

Liveweights of cattle grazing improved or native pasture are presented in the following figure. Small liveweight changes were recorded during the dry season for cattle grazing both pastures. Over the following period (late dry season), liveweight losses were recorded for both pastures, although the cattle grazing native pasture lost significantly more weight than those grazing improved pasture. During the wet season, cattle grazing improved pasture gained significantly more weight than the cattle grazing native pasture.

Supplementation of cattle grazing improved pasture with minerals showed no benefit. Analysis of the pasture of D. intortum indicated mean nitrogen and phosphorus values of 18.1 and 2.1 g kg DM^{-1} and 18.3 and 2.1 g kg DM^{-1} for samples collected in February and May respectively. Cattle gained liveweight at the mean rate of 108 g $head^{-1}$ day^{-1} over 360 days and a total of 23 calves were born (three of which died) during the experimental period.

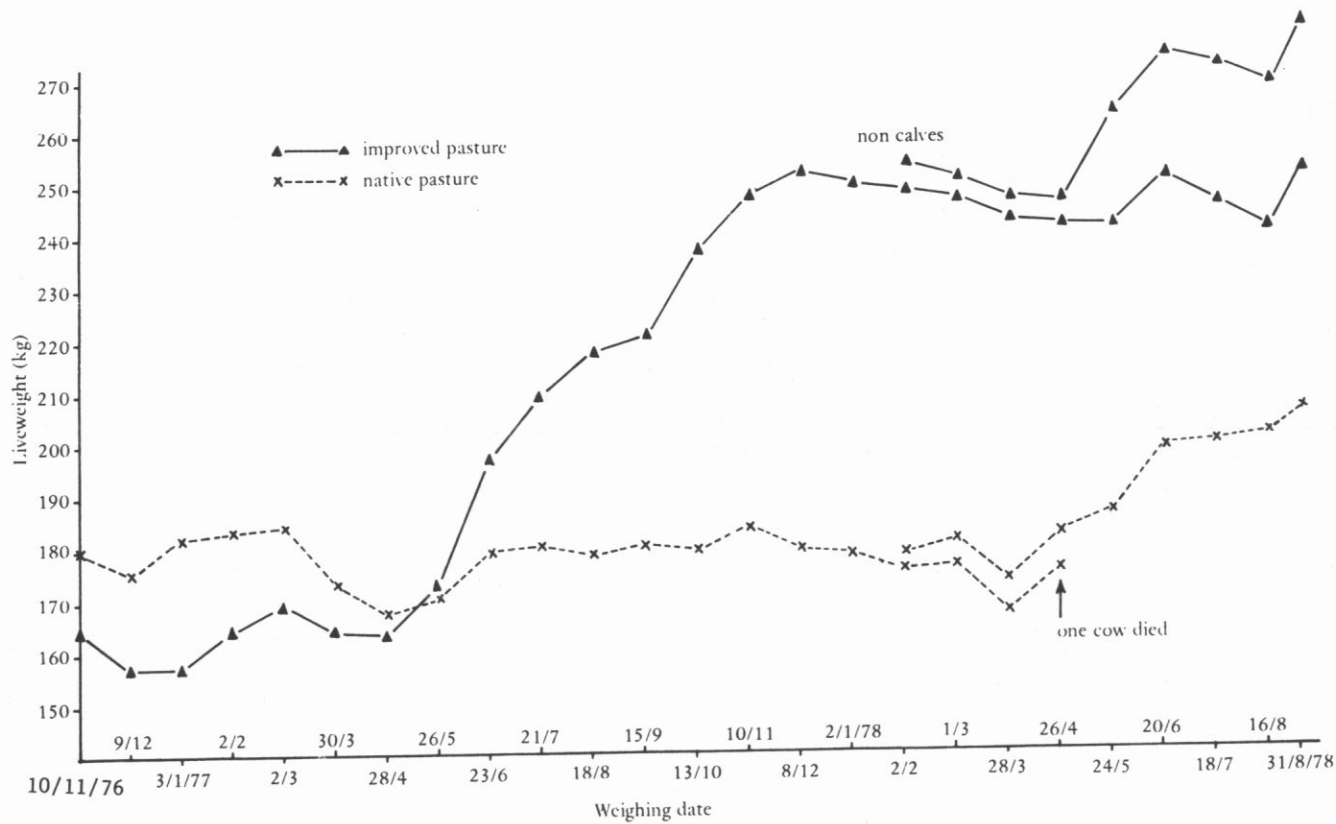
In another study, the mean proportions of pasture components and total dry matter on offer for two grazing pressures (210 kg and 420 kg liveweight per ha) at five sampling dates declined over time. The proportions of improved legume and grass increased while that of native grass (Imperata cylindrica) decreased and that of weeds remained fairly constant. The proportion of native grass in the sward decreased more rapidly at the higher grazing pressure than it did at the lower stocking rate. Dry matter availability decreased over the period of the experiment, particularly at the higher grazing pressure; bare ground was recorded in the high but not the low grazing pressure treatment.

The mean increases in liveweigh gain per head for cattle at the two grazing pressures, some of which received anthelmintic treatment are presented in the following table. There were no significant interactions between grazing pressure and anthelmintic treatment. During the dry season (December to March), trends toward higher liveweight gains for cattle at the lower grazing pressure and receiving anthelmintic treatment were not significantly different. During the wet season (June to November), there were significant differences between grazing pressure treatments and anthelmintic treatments.

Mean liveweight gains of cattle grazing improved pastures at two grazing pressures under two anthelmintic treatment regimes.

Grazing pressure (kg bodyweight ha^{-1})	Anthelmintic	Liveweight change (g $hd^{-1}day^{-1}$	
		December-March	June-November
210	+	$+58^{a}$	565^{a}
	-	-85^{a}	337^{b}
420	+	-13^{a}	297^{b}
	-	-45^{a}	189^{c}

Means within a column followed by the same superscript do not vary significantly ($P > 0.05$).



Mean liveweights of cattle grazing either improved or native pasture.

PERSISTENCE OF IMPROVED PASTURES

Invasion by _Eupatorium adenophorum_ is a problem of improved highland pastures even at moderate stocking rates (one beast ha^{-1}, i.e. a mean of approximately 200 kg bodyweight ha^{-1}) and is usually more severe in paddocks which have been grazed for a longer period. Both the low dry matter availability and high degree of weed invasion suggest that the grazing pressures may have been too high in many experiments and one study confirms that a mean grazing pressure of 210 kg bodyweight ha^{-1} leads to decreasing pasture availability and that 420 kg bodyweight ha^{-1} leads to overgrazing. On the other hand, some pastures show no tendency toward increasing weed invasion or decreasing dry matter availability which may be attributed to the differences between sites.

Control of weed invasion of improved pastures requires high management inputs and may prejudice the technical and economic efficiency of their use in the highlands where inputs into cattle raising have traditionally been very low.

ANIMAL PRODUCTION FROM IMPROVED PASTURES

Liveweight gains on the improved pastures during the initial dry season of grazing are often low considering the high availability of legumes and in the wet season, superior liveweight gains of the cattle grazing improved pastures do not seem to be related to any one pasture parameter. Faecal nitrogen analyses indicate higher nitrogen contents of the diet of cattle grazing improved pasture as well as apparently lower phosphorus contents. It is conceivable that the primary response from the improved pasture may be to higher dietary nitrogen during the wet season (May to November); supplementation with improved pasture or minerals may thus be of value in the wet season as distinct from the dry season.

The lack of significant differences in liveweight change between different pasture types in the wet season is probably due to a combination of the decreasing dry matter availability of improved pastures under grazing. The levels of cattle productivity estimated in different experiments varies greatly; this may be due to site variation and higher levels of management inputs particularly with regard to weed control. Analyses of extrusa obtained from oesophageally fistulated cattle indicate no significant differences in nitrogen content and _in vitro_ digestibility of native and improved pastures (eg. refer to the following table). However, differences in cattle productivity from these pastures may be related to differences in dry matter availability.

Mean nitrogen content, *in vitro* digestibility, number of bites per minute and bite size for cattle grazing improved pastures at two grazing pressures at four seasonal periods.

Seasonal Period	Grazing Pressure and Measurement: 210 kg bodyweight ha^{-1}				420 kg bodyweight ha^{-1}			
	Nitrogen (g kg DM^{-1})	*In vitro* digestibility (% DM)	No.bites (min^{-1})	Bite Size (g DM)	Nitrogen (g kg DM^{-1})	*In vitro* digestibility (% DM)	No. of bites (min^{-1})	Bite Size (g DM)
Mid-wet season	20.0^{a}	64.8^{a}	15.4^{a}	0.40^{a}	21.3^{a}	52.3^{b}	12.6^{a}	0.37^{a}
Late-wet season	14.9^{b}	49.6^{b}	11.6^{ab}	0.56^{a}	17.9^{b}	41.0^{b}	12.1^{a}	0.44^{a}
Cool-dry season	11.7^{b}	70.8^{a}	8.5^{b}	0.63^{a}	7.9^{c}	68.6^{a}	11.9^{a}	n.a.
Hot-dry season	19.1^{a}	39.6^{b}	8.4^{b}	0.50^{a}	14.5^{b}	42.1^{b}	10.0^{a}	0.56^{a}

Means within a column followed by the same superscript do not vary significantly ($P > 0.05$)

n.a. = not available

MINERAL SUPPLEMENTATION AND ANTHELMINTIC ADMINISTRATION

Supplementation with minerals on a monthly basis is an accepted technique (McDowell, 1976), suited to remote regions. The lack of any liveweight responses to supplementation in the highlands belies the fact that salivary sodium levels are below the suggested critical level of 100 meq l^{-1} (Alexander, 1973).

The principal worm groups determined to be present in the faeces were trichostrongylids (eggs), amphistomes (eggs) and coccidia (oocysts). Levels were higher in the faeces of cattle not receiving the anthelmintic (up to 800 egg g^{-1}); occasional low levels of infestation were recorded in the cattle receiving the anthelmintic. Cattle grazing native pasture consistently showed low levels of infestation. Administration of anthelmintic increased liveweight gains of cattle grazing native pastures during the wet season when faecal egg counts were highest. This is consistent with the results of research conducted at the same site with sheep (Falvey and Rietschel, 1978).

It can be concluded that improved pastures can increase cattle productivity per unit area by at least fifty fold. However, it is unlikely that return per unit area is of primary importance to hilltribes concerned with cattle because they lack title to the land and free range grazing land is usually readily available. Technical constraints to the use of improved pastures such as management of grazing pressure, anthelmintic treatment and weed control can be overcome but socially, the financial and labour inputs necessary for continued high levels of animal production may be unacceptable. Strategic supplementation with improved pasture or minerals to cattle grazing native pasture may be alternatives to set stocked areas of improved pastures that are more socially acceptable and more economic.

CHAPTER 8

Sheep

INTRODUCTION

Sheep have probably been present in Thailand for several hundred years although the population was estimated to be only about 10,000 in 1963 (Coop, 1976).

Coop (1976) noted the similarities between the sheep of Thailand and the Indian and Arabic breeds, and a probable migration route down from the southern provinces of China to Malaysia about 5000 years ago has also been suggested by Devendra (1975). The latter hypothesis is substantiated by some physical characteristics such as tail shape (Devendra, 1975) and wool type (Smith and Clark, 1972). Epstein (1969) has classified the sheep of China and noted the similarities of Thai sheep to the thin-tailed Tibetan type sheep found in China. It is possible, however, that sheep in Thailand have come from both the north and the west. Hoare et al. (1976) have described some physical characteristics of two sheep breeds indigenous to Thailand which for the purposes of comparison were referred to as Thai Indigenous and Bangladesh-Burmese. The latter breed was so named for its close physical resemblance to sheep of the Indian subcontinent and Burma region from where the breed may have migrated to Thailand with eastward migration of Muslims. The principle physical differences between the two breeds are tail length, ear conformation and wool cover (Hoare et al., 1976).

The indigenous sheep of this region have evolved under a system of low nutrition which has produced breeds that can survive on a diet low in nitrogen, through the mechanisms of low endogenous losses and relatively high values for proteins (Devendra , 1976).

In lowland Thailand, most sheep are kept by Muslim traders who cater for the meat trade amongst the relatively small Muslim population of Thailand. Thus the main concentrations of sheep raised on a permanent basis tend to be in those provinces where the population of Muslims is higher, such as the three southernmost provinces of Thailand. There

is, in addition to the sheep raised for meat production, some movement of sheep across the border with Burma at Mae Sod (Falvey, 1977), although movement of cattle and buffalo is of much greater importance. These sheep primarily sold to Muslims and others in Bangkok.

Other sheep breeds have been imported from time to time in small numbers, notably the breeds; German Merino, Polworth and Dorset Horn. In all instances these sheep have been crossed with native sheep in attempts to increase the productivity of individual animals.

SHEEP IN THE NORTHERN HIGHLANDS

The estimated population of sheep in north Thailand in 1963 was 1600 (Coop, 1976) while in 1976 Hoare _et al_. (1976) estimated the total highland flock to be approximately 1000 head with the largest individual flock being 170 sheep. Sheep may have been introduced to the highlands during the period of migration discussed by Devendra (1975), however, these sheep cannot be traced directly to the sheep present in the highlands today. The present occupants of the highlands, commonly referred to as hilltribes, have moved into the region only during the last one hundred years or so. Previously, it seems likely that the region has passed through a stage in which there were very few permanent inhabitants although there are suggestions of settled occupation at some much earlier dates (Penth, 1977).

The present flocks of the highlands have their origins in sheep brought from the lowlands of Thailand and, in some instances, other countries. Sheep were introduced to Karen villages by the American Baptist Mission in about 1966. These sheep were primarily of the breed called Thai Indigenous although some Dorset Horn and Polworth rams were imported later from America and Australia respectively (Nelson, 1976a). In 1970, sheep were donated by His Majesty the King to 17 highland villages (Posri _et al_., 1976).

The rationale behind the introduction of sheep to highland villages has been varied and, in fact, all the flocks established have been, to a large extent, experimental. Their introduction was based largely on subjective examination of the biological and sociological system operating. Goats have traditionally been raised by hilltribe people for several decades although development of this industry is not favoured by some agencies (Falvey, 1977). Coop (1976) felt that sheep may be less damaging to the environment and possibly provide an additional product in the form of wool. The cost of an individual sheep being less than that of cattle and buffalo, was considered to be an additional reason for their introduction as this would potentially enable more individuals to become owners (Hoare _et al_., 1976).

Despite more than ten years experience in sheep raising, the industry is not providing any appreciable increase in total village income in most instances.

Ownership

Sheep in highland villages have, in almost all cases, been placed there by agencies interested in development. The largest flock of sheep in the highlands is part of a project sponsored by His Majesty the King while other flocks have been introduced by the American Baptist Mission (Nelson, 1976a), and development and research aid projects (Irwin, 1976; Hoare *et al.*, 1976).

In villages receiving assistance from missionaries, flocks have been introduced into villages on the basis of commercial or local Church ownership. A shepherd is usually paid a small wage by the village to care for the sheep. Nelson (1976a) reports that this system has proved successful only in villages with strong leadership.

Management

Management of sheep in the highlands is generally of a low standard. Such a situation was foreseen by Coop (1976) who suggested that, considering the lack of education of highland people in sheep management and the liklihood that sheep will have to survive without parasite treatment, native sheep were to be preferred over European breeds. Villagers who have had some experience in sheep raising claimed in some cases that sheep were easier to manage than goats although others claimed the opposite (Falvey, 1976). In fact such comparisons are not entirely valid because the management inputs for livestock particularly ruminants are almost negligible.

It is more common for management to be orientated towards crops than livestock; fencing will be to exclude livestock from crops rather than to enclose them on pasture. In this instance it was claimed that sheep can be kept off crops with more ease than can goats (Falvey, 1976). Nevertheless, the grazing habits of sheep in the highlands were found to be similar to those of goats including the browsing of tree leaves (Falvey, 1976).

Goats are commonly allowed free access to rangeland surrounding villages (Falvey, 1977) without any supplementary feeding or health care. Sheep raised under similar conditions show high mortality rates. Nelson (1976a) has similarly noted that most problems encountered with sheep raising in the highlands can be traced to improper management.

Variations in management in terms of castration are also evident (Falvey, 1976). This common practise for goats (Falvey, 1977) has apparently not been adopted for sheep in all cases. Herding is not practised for goats but is in some cases (where a shepherd is employed) for sheep. The sheep prefer to graze the low growing grasses such as *Paspalum orbiculare*, *P. distichum*, *P. longiflora* and *Cynodon dactylon* that tend to occur around villages, in addition to the ubiquitous tall grass *Imperata cylindrica*.

Management Systems

Coop (1976) has noted the night housing of sheep is favoured to prevent losses by theft, wandering away and predators. The qualities of such housing have been amplified by Nelson (1976a) who also suggests that sheep kept on grazing areas under proper shepherding by means of a portable pen may suffer less from disease and infections than sheep housed in the same pen each night.

It has been suggested that the management systems common in Malaysia and Indonesia where children herd small flocks may be applicable (Coop, 1976). Having children tend flocks has not proved completely successful for cattle in some development projects (eg Hoare and Thanyalappitak, 1978) because during periods of peak agricultural activity the children will be required to work in the fields and so leave the flock unattended. Herding is generally viewed as a task of low status in the highlands (Wongsprasert, 1970).

Diseases

Goats have been said to be affected by foot and mouth disease, maggot infestation of open wounds but little else (Falvey, 1977). The general standard of health of sheep in the highlands has, however, not been as high as that of goats. Sangwien *et al*. (1976) reported a foot abscess outbreak which caused some lamb mortalities. An estimated ten sheep had also succumbed to the infection associated with maggot infestation of wounds caused by rams fighting or dog bites (Sangwien *et al*., 1976). The problem of dog bites and maggot infestation has been mentioned by several authors as a major problem with sheep in village situations (*eg* Irwin, 1976; Nelson, 1976a), although as Nelson (1976a) notes "the incidence of dogs biting the sheep is decreasing as the dogs become accustomed to the sheep around the village".

Nelson (1976a) has noted that the hot, damp crowded pens into which sheep are often herded each night, and sometimes for part of the day thereby reducing grazing time markedly, enhances the spread of many diseases and parasites. Another danger to sheep, perhaps associated with progress in another field, is the indiscriminate disposal of small plastic bags around villages. Hoare *et al*. (1976) records an instance of a sheep that died from an obstruction of the digestive tract by 17 plastic bags and one piece of plastic belt.

Other specific diseases that can affect sheep in the highlands are largely unidentified. Satayaphan (1976) listed 29 diseases that may have occurred in a large flock of sheep raised in the highlands for several years. Six types of external parasites and ten types of internal parasites are also listed.

Internal Parasites

The importance of internal parasites in sheep in the highlands has been suggested from post mortem examination of sheep that have died from various causes (Hoare *et al*., 1976).

The damp environment of the highlands and the cooler average temperatures compared to the lowlands also suggests the potential importance of internal parasites.

An experiment in which a group of sheep receiving regular anthelmintic treatment were compared with untreated sheep indicated large productivity differences (Falvey and Rietschel, 1978). Deaths were recorded only in the untreated group of sheep and the lambing percentage of the treated group was higher than that of the untreated group. Liveweight gains were higher for the treated group and when the data was analyzed on a breed basis, this difference in liveweight changes was significant ($P < 0.05$) for one breed. There did appear to be a difference between breeds in terms of the type of response recorded. Crossbred sheep (German Merino x Thai Indigenous) showed a liveweight response while two indigenous breeds showed a response in terms of reduced mortality. Faecal worm egg counts of sheep not treated with anthelmintic and post mortem examination of sheep that died during the experiment or were slaughtered at the conclusion of the experiment indicated the presence of _Fasciola_, _Paramphistomum_, _Trichostronglus_ and _Cysticercus tenuicollis_.

Falvey and Rietschel (1978) speculated that the internal parasites of sheep in the highlands has most probably been brought from lowland areas when sheep are brought to the highlands. The investigation emphasized the importance of internal parasite control for sheep in the highlands.

While chemical control of internal parasites is probably uneconomic and could not be easily implemented, other factors such as ventilated, clean housing and rotational herding of sheep on pasture may assist in controlling any large build up of parasite numbers.

PRODUCTIVITY OF SHEEP IN THE HIGHLANDS

The productivity of sheep in the highlands is low. General observations indicate that crossbred sheep are more productive than the native sheep with differences between crossbred sheep being attributable to management inputs. Coop (1976) noted that if European sheep were to be imported, they should be restricted to the higher altitudes (over 1300 m) and protected from the heavy storms. In fact, experience with purebred European sheep has shown that, under the common low levels of management most animals cannot survive. Crossbred sheep however, can survive and may be more productive than the indigenous breeds.

Some preliminary production data on sheep in the highlands has produced relationships with correlation coefficients of 9.97 and 0.80 between heart girth and liveweight, and height and liveweight respectively (Falvey, 1976). While these relationships were not as accurate as determined for goats in the highlands (Falvey, 1977), they are of the same order of correlation as produced from work in India (Singh and Singh, 1977). Investigations in Malaysia, presumably on sheep of similar breeds, indicated lower levels of correlation

(Devendra, 1975). More recent studies have indicated correlation coefficients of a higher order for sheep of the four breed types raised in the highlands (Falvey and Hengmichai, 1979).

Liveweights

Falvey and Hengmichai (1978) have reported productivity data for sheep of three breeds present in the highlands. Of the three breeds; German Merino x Thai Indigenous, Bangladesh-Burmese, and Thai Indigenous (Hoare *et al*., 1976), the German Merino x Thai Indigenous sheep showed significantly ($P < 0.05$) higher liveweight gains than the two indigenous breeds which did not differ significantly ($P < 0.05$).

The mean liveweight gains of lambs born to sheep of the three breeds and sired by German Merino x Thai Indigenous rams, again indicated the superiority of the German Merino x Thai Indigenous sheep.

Mature liveweights of approximately 41 kg, 23 kg and 24 kg for the German Merino x Thai Indigenous, Bangladesh-Burmese and Thai Indigenous breeds respectively were recorded. Posri *et al*. (1976) reported similar results for the Thai Indigenous breed where females averaged about 24 kg and males 27 kg at maximum weight. Liveweight gains of these Thai Indigenous sheep were estimated to be approximately 46 g/head/day which compare with figures of 10-46 g/head/day (Hoare *et al*., 1976) and 6 g/head/day (Hoare *et al*., 1977). Mean liveweight gains for the German Merino x Thai Indigenous breed of 65 g/head/day (Hoare *et al*., 1976) and 48 g/head/day (Hoare *et al*., 1977); and 12-43 g/head/day (Hoare *et al*., 1977) for the Bangladesh-Burmese breed have been presented.

While these figures are below the levels of productivity commonly quoted in sheep producing areas of the world, they are sufficient for reasonable levels of production. It should however be noted that the figures of Falvey and Hengmichai (1978) are from sheep receiving regular anthelmintic treatment and raised in a clean ventilated nighthouse.

Reproduction

Births have been recorded throughout the year with peak incidence of lambing occurring during the months of February and March (Falvey and Hengmichai, 1978) or May-July (Posri *et al*., 1976).

Posri *et al*. (1976) recorded a lambing percentage of 62% for Thai Indigenous ewes while Falvey and Hengmichai (1978) recorded figures of 78, 92 and 65 for the German Merino x Thai Indigenous, Bangladesh-Burmese and Thai Indigenous breeds respectively. It was also noted that the German Merino x Thai Indigenous ewes showed a greater capacity to lamb twice within any 12 month period.

Lambs born to ewes of the German Merino x Thai Indigenous breed were significantly ($P < 0.01$) heavier than those born to the ewes of the indigenous breeds and male lambs tended to be heavier than females. Within the male lambs, those born to Thai Indigenous ewes were significantly ($P < 0.05$) lighter than those born to ewes of the other two breeds. The ratio fo the sexes of lambs born to ewes of the three breeds also varied, with equal numbers of each sex being born to ewes of the German Merino x Thai Indigenous breed while for both of the indigenous breeds, more male than female lambs were born (Falvey and Hengmichai, 1978).

The effect of the lambing percentages, the sex ratio of lambs and their survival rate on productivity in the long term indicate that the German Merino x Thai Indigenous breed is superior to the indigenous breeds. A very low incidence of twinning was recorded in common with the results of Devendra (1975).

Mortality

The work of Falvey and Hengmichai (1978) indicated a greater proportion of deaths in the Bangladesh-Burmese genotype than in the Thai Indigenous genotype which in turn showed a higher proportion than the German Merino x Thai Indigenous genotype.

Nelson (1976) noted a high mortality rate in lambs within two weeks of birth which he attributed to poor nutrition of the ewe. The data of Falvey and Hengmichai (1978) support this suggestion and indicates the mechanism of low birth weights in lamb mortality.

Wool Production

Wool production is low, although the fleece of crossbreed sheep is more easily shorn. The mean greasy yield of 1.03 kg (range 0.6-1.3) recorded by Falvey and Hengmichai (1978) compares with the range of 0.8-1.4 for Malaysian sheep (Devendra, 1975) and 0.9-2.3 for Pakistan sheep (Ashfaq, 1976). In addition to these low wool yields the low quality of the wool also reduces the potential for this industry. some authors have noted the superior quality of wool cut from sheep crossed with European breeds (eg. Hoare *et al*., 1976).

Carcass Characteristics

Carcass evaluations on the four breeds of sheep present in the highlands have been conducted by Falvey and Hengmichai (1979). The Thai Indigenous breed showed higher dressing percentages at intermediate liveweights while at higher liveweights, the German Merino x Thai Indigenous breed showed higher dressing percentages. Sheep of the Polworth x Thai Indigenous breed type showed the lowest dressing percentages at higher liveweights.

The proportion of bone in the carcass weight varied similarly with liveweight for all breed types, decreasing from about

35% to 21% over the liveweight interval of 14-32 kg. The proportion of meat in the carcass showed only a very slight increase with liveweight for all breed types, and was of the order of 70%.

The total edible proportion of each animal increased with liveweight for all breed types. At higher liveweights German Merino x Thai Indigenous sheep showed the highest and Polworth x Thai Indigenous showed the lowest proportions, while at intermediate weights the Thai Indigenous breed type showed the highest proportions. Variations between breed types were not great and the mean edible-meat yield was about 45% of liveweight. Carcass evaluation conducted previous to this study have shown lower dressing percentages for sheep of similar weights (Falvey and Hengmichai, 1978). Evaluations of the carcasses of the indigenous sheep of Malaysia (Devendra, 1975) also showed dressing percentages below those recorded in this study although studies in India and Sudan (quoted in Devendra, 1975) showed similar yields. Devendra (1975) notes that these variations may be related to the age of the animal at slaughter.

The mean meat to bone ratio of the sheep breeds studied was 2.8:1 which is higher than the value of 2.1:1 calculated for Malaysian sheep (Devendra, 1975) and the value of 2.5:1 calculated for some Indian sheep (Singh, Mathur and Bohra, 1973). Thus the sheep of this region appear to provide higher per animal yields compared to related breeds in Asia. The relative distribution of meat cuts in the carcass is probably of little importance to the Thai market and the small hotel trade most likely requires meat of a higher quality than can be produced under highland conditions at present.

UTILIZATION OF PRODUCTS OF HIGHLAND SHEEP

Wool

The fleece of the indigenous sheep of Thailand is of poor quality due to such factors as high average fibre diameter and staple length (Anon, 1978). Productivity is similarly low with a growth rate estimated at 10-15 cm per annum (coop, 1976). The sheep have bare bellies and hair is shed if not shorn,which is a common occurrence in situations where the fleece cannot be sold.

Karen people have traditionally spun their own cotton gathered from wild cotton trees and woven garments from it. Nelson (1976b), when working with the Karen, has adapted the process to sheep hair using both traditional and imported equipment. The primary product is blankets which are used by the Karen themselves or sold, although much hair still remains unsold. Blankets made from this hair are prickly and cannot be worn next to the skin although they are much warmer than cotton. It has been estimated that one blanket per year, of value 160 baht (US$ 8) can be made from the hair of two sheep (Coop, 1976). Other uses for this hair are batting (stuffing)

quilts and possibly rope manufacture and compression into felt for floor coverings and saddle blankets.

While the world market requirements for coarse wool are largely unspecified (Turner and Dunlop, 1974), Turner (1974) has suggested that other countries such as Australia may be interested in the coarse wool breeds to introduce greater genetic diversity into their sheep industries.

Hoare et al. (1976) has noted that crossbred sheep such as German Merino x Thai Indigenous sheep, produce a fleece almost free of kemp fibres which is more suitable for spinning and weaving. Nevertheless, it has been estimated that in 90% of the villages where sheep are raised, fleeces are not cut because the wool or hair, as the case may be, cannot be readily sold (Mann, 1976).

It appears that unless production of wool is large, sale as greasy wool will be difficult. Home consumption of wool or hair in hilltribe villages is the most likely use of the product and, if wool or hair production is considered alone, the industry will most probably remain one of subsistence.

As noted previously both the quality and quantity of wool and hair produced are low. It is apparent that the market for such produce is not limited by the low quality of the wool alone but also, and perhaps to a greater extent, to the small quantities produced. Low quality wool is possibly a saleable product in large quantities. Nelson (1976b) has noted that while there is no established wool market in Thailand where wool can be sold for a known price, there is a carpet manufacturing industry in the country that at present imports wool. Hair shorn from the indigenous breeds of sheep contains a large proportion of kemp fibres that will not accept dye easily. The fleece of crossbred sheep however, would be acceptable.

A small local trade in wool has sprung up recently where Karen tribes people who have been raising sheep under the guidance of missionaries, have found that they cannot produce enough wool for their spinning and weaving activities and have therefore sought wool from other projects.

Meat

The meat yields of sheep raised in the highlands is similarly low. The meat is lean and can be sold to a limited market in the form of sporadic buying by the hotel trade. There is however a market preference for imported lamb by this trade. The main consumers of sheep meat in Thailand are Muslims who insist on slaughtering the animals themselves. In most cases however, Muslim people raise sheep and goats themselves to supply this market. Thus the market for meat, as for wool or hair, is limited.

Coop (1976) noted that meat consumption in many hilltribe villages was low and that sheep could play an important role in increasing the dietary protein intake of highlanders.

It was calculated that at 80% lambing and slaughtering at 23 kg, one ewe per two persons could produce about 4.5 kg of meat per person per year. Coop 91976) however, noted that the projected flock sizes required from such calculations exceed the size that could be supported around one village.

The present practise of goat raising in some highland villages in fact fills this subsistence role as well as providing a means of obtaining some cash in time of need (Falvey, 1977). While sheep may be more easily kept out of cropping fields, their lower productivity and higher management requirements render the prospects for large expansion of the sheep industry to the exclusion of goats, unlikely.

It has been suggested that sale of sheep for meat may be more attractive than home consumption because an 11.5 kg carcass can be sold for 300-350 baht to the hotel trade in Chiang Mai and Bangkok (Coop, 1976). It was even suggested that intensive fattening systems may be economic. Indeed these prices are attractive; however they do not represent a price determined by supply and demand.

Muslim animal traders and missionary projects sell dressed carcasses at 35 baht per kg but these sales are largely solicited among foreign residents. Posri et al. (1976) noted that of eight sheep sent for slaughter in August, 1975, only three had been sold at 400 baht per head by September, 1976. This appears to have disillusioned the villagers involved in the project who refused to make any improvements in their substandard management until the sheep proved saleable.

A more realistic price for sheep meat may be something competitive with pig and cattle meat, say 30 baht per kg. Goats, which produce a similar carcass to sheep, are sold at about 200 baht per head for animals of similar sizes.

Perhaps the artificially high prices asked for sheep have been derived from the appraently high purchase price for breeding stock. Hoare et al. (1976) has presented figures on the sources and prices of some sheep purchased in Chiang Mai. Ewes and lambs of the Bangladesh-Burmese breed cost a mean of 43 baht per kg liveweight while the Thai Indigenous breed cost a mean of 23 baht per kg liveweight. At that time the price of cattle was between 9 and 12 baht per kg liveweight.

To sell to a wider market that does not prefer sheep meat to the other meat available, would most likely require a regular supply of meat at a price substantially lower than that presently asked.

THE FUTURE OF THE HIGHLAND SHEEP INDUSTRY

Technically speaking, productive sheep can be raised in the highlands, however the potential for expansion of this industry is limited by the restricted markets for both meat and wool (Falvey and Rietschel, 1978). Should marketing

problems be surmounted the probable extension barrier in attempting to introduce levels of management higher than those common for goats must be faced. It may be expected that those hilltribe people interested in raising small ruminants are those that have already obtained goats through their own initiative. To raise sheep in place of goats under a higher level of management for an apparently similar species of animal, would require a large extension effort on the part of supportive government agencies. Such an effort could probably not be justified at the present time.

In Malaysia, Devendra (1975) concluded that the future of sheep production rests with their upgrading from one of present unimportance to one of significance. In Thailand such a conclusion cannot be drawn except perhaps for some provinces in southern Thailand where the muslim population causes a higher demand for sheep. For the highlands of north Thailand sheep will, in all probability, remain a very small industry. At this stage further research and investment in development of the industry seems unwarranted.

CHAPTER 9

Conclusions

SOCIOLOGICAL PERSPECTIVE

Creation of stable agriculture in the highlands is required because the traditional agricultural system of shifting cultivation is not able to service the increasing population. Besides this humanitarian need to improve the productivity of the region, there are political needs to stabilize the residents of border regions and, in some cases, to provide alternatives to opium production. Development of the cattle industry is one component of a stable agricultural system that could produce an income and more protein from areas not suitable for cropping.

The lack of commercial development in the cattle industry can be attributed to the historical unimportance of cattle in highland economies except in the role of capital reserves and sacrificial animals. Lack of commercial attitude to cattle is thus the first constraint to development of the industry on a small holder basis within the region. Self motivation to increase inputs in the industry is increasing but the low productivity of cattle acts to discourage much development. Differences between ethnic groups exist and it is suggested that the Karen ethnic group are more likely to enter commercial cattle raising than the Meo, who continue to follow their traditional custom of sacrificing cattle in funeral celebrations. The Lisu like to own large numbers of cattle and may thus also be more ready to accept a commercial orientation provided their status requirements of cattle numbers were maintained.

Changing to a commercial enterprise, even gradually, is not considered to be possible until the constraints of disease, theft, predators and nutrition can be removed. It is easy to suggest that inputs to overcome the first three of these constraints are available. However, they are not practised possibly because productivity of individual animals is restricted by poor nutrition and producers do not appreciate this problem because no obvious means of increasing productivity through nutrition have been demonstrated to them on a wide scale.

Social attitudes in the highlands are changing as contact with other cultures increases; the social constraints to development of the cattle industry will therefore disappear, particularly among those ethnic groups already interested but not practising this concept. The results of recent research determine strategies that can increase cattle productivity by catering for the need for development and demonstrating that a commercial attitude to cattle raising can be practical.

CATTLE OR BUFFALO DEVELOPMENT

Buffalo appear to be more productive than cattle in the highland environment. A simple comparison of the two species indicates that, in terms of the rate of biomass increase, the lower reproductive rate of buffalo is more than compensated for by higher growth rates. Rufener (1971) found the opposite trend in north eastern Thailand where cattle were of a larger size and exhibited higher growth rates. On the basis of the prices recommended by villages, buffalo appear to be much more profitable than cattle. However, the scope for raising buffalo in the highlands is limited by the environment. In highland areas closer to the lowlands, buffalo are kept for an interactive trade to the benefit of both parties. These areas are probably more suited to the raising of buffalo because of a greater abundance of damp areas and wider availability of plant species. The more remote areas of the highlands are probably less suitable for buffalo and the hilltribes prefer to raise cattle in these regions. The lower price of an individual cattle beast is an added attraction for this species because it is easier for poor farmers to enter the industry. Thus while buffalo may appear to be more attractive in terms of economic returns, the scope for development of the cattle industry is probably greater. Improved productivity of cattle in the highlands seems feasible by removing some of the constraints isolated in the survey. Disease is an important problem that is soluble using known techniques and vaccines produced within Thailand; plans for the implementation of an animal health scheme have been prepared by Ashfaq and Kitiwan (1976). Theft and predators could also be controlled by greater management inputs. Technically, the principle area where current knowledge is lacking is nutrition. Improved management techniques and animal health care would be expected to have a much greater inpact on development of the industry if nutrition was also improved.

CONSTRAINTS OF THE HIGHLAND RUMINANT INDUSTRIES

The ruminant livestock industries as they exist today in the highlands have evolved over a long period of time under the constraints of the area; four of the main constraints are: disease, theft, predators and nutrition.

Infectious Diseases

The finding of Cockrill (1974) that in general, buffaloes are more susceptible to disease epidemics than are cattle is true in the highlands. The incidence of disease epidemics in the highlands seems to be low, possibly because of the localized nature of the industry around villages with only limited contact between the livestock of different villages. Symptoms of haemorrhagic septicaemia, to which buffaloes are probably more susceptible than cattle, are described by owners of cattle and buffalo in some instances. A vaccination programme has been initiated in the lowland areas against this disease but as yet only a small number of highland herds have been vaccinated. Foot and Mouth Disease is commonly mentioned by villagers as a potential problem although the actual incidence of the disease has not been determined. Brucellosis or contagious abortion is possibly responsible for some of the abortions said to occur and incidences of brucellosis as high as 50% have been suggested for some groups of cattle entering Thailand from Burma. Some abortions in buffaloes are probably caused by the fact that they are often required to work during late pregnancy. Deaths of young calves are almost invariably linked with white scours, particularly buffalo calves. Maggot infestation of wounds and the navals of newborn stock is also of importance during the warmer months of the year as is pink eye. Other diseases, such as black leg and vibriosis have been suggested to be of possible importance to highland cattle (Coates, 1974) but no records of their occurrence apparently exist.

Theft

Theft of livestock is roughly correlated to the proximity of villages to lowland areas or to roads, with variations being attributable to the care taken in tending stock. In most villages, thefts are said not to have been a problem until roads were constructed nearby. Stock were either led away to be tended or sold by the thief, or shot and butchered. Usually thieves were said to be Khon Muang people who live in the lowlands or lower altitudes of the highlands. However, in some instances conflict between two rival villages can develop to the stage that thefts of small livestock occur. Most highland people are reticent to reveal the identity of the suspected or in some cases, known thief of their stock.

It is considered futile to report thefts to the police. A small proportion of thieves are caught and their punishment has ranged from being forced to pay for the stock stolen to spending two years in prison. Thefts seem more likely to occur during the period of February to May when many lowland dwellers do not have much pressure of agricultural work. Tending of stock is the most practical answer to this problem at present.

Predators

Predators in the form of leopards and possibly tigers are still active in the highlands. The incidence of attacks by predators is decreasing rapidly as the area of forest decreases and human population increases. At the present time, they are only a regular problem in the more remote villages although occasional attacks occur in more accessible areas. The incidence of predator attacks is easily exaggerated especially in cases where cattle are not adequately tended; predators attacks are rare when humans are present. Buffalo can apparently protect themselves against predator attack to a greater extent than can cattle.

MEANS OF IMPROVING NUTRITION

Strategies

The cattle industry of the highlands is small and inefficient in an economic sense. Managerial inputs are low and, from a technical viewpoint, the principal constraints on productivity are nutrition and disease, the latter of which could easily have been controlled in the past by use of existing technology. Social constraints, such as the use of cattle as religious sacrifices, investments that are seldom realized or as symbols of status, are significant problems in the development of the cattle industry.

Biological studies have confirmed the low levels of both pasture and animal productivity. Variations in liveweight gain are related to the nutritional quality and availability of the *Imperata* dominant (native) pasture. Means of improving the nutrient status can be divided into two approaches. The first involves the use of improved pastures to increase feed intake and quality, and the second involves strategic supplementation with specific deficient nutrients to cattle grazing native pasture.

Improved pastures are more productive than native pastures, increasing total feed availability and thereby allowing higher stocking rates and increased liveweight gains. A major constraint to the utilization of this system is weed invasion, a problem also found with native pastures under higher grazing pressures. The absence of weed control would prejudice the persistence of the improved pasture and result in decreased returns to the high capital investment required for improved pasture development. The inputs of a grazed improved pasture system must include fertilizer, fencing, anthelmintic control and close supervision. The social tradition of minimal management and financial inputs for livestock is at variance with these requirements and it is therefore concluded that conventional improved pastures, while technically feasible may not be socially acceptable at the present time.

Supplements containing minerals and energy increase the productivity of the cattle grazing *Imperata* dominant (native) pastures and the levels of supplement necessary are economically

feasible for use in this environment. The two major deficiencies of sodium and feed intake in cattle grazing native pastures provides the basis for practical recommendations to increase cattle productivity. It also suggests that cutting and feeding as a supplement to night-yarded cattle may be a more useful role for improved pasture than extensive sowing of pasture for grazing stock. It is recommended that cut forage and sodium be fed as supplements to highland cattle when they returned to their night camp.

Salt (sodium chloride) is a cheap and convenient means of providing supplementary sodium. The high costs of fencing and fertilizer for improved pasture would be reduced where small areas of pastures for daily cutting are established near cattle yards. Hand cutting of small plots would also overcome the problem of selective grazing by cattle in weed infested pasture. Similarly, forage other than improved pasture could be utilized in this role. The major benefit of feeding improved pasture in this manner is that the average quality of such material is higher than that of cut native pasture (mainly Imperata cylindrica).

The two strategies that can be used to improve the nutrition of cattle in the highlands each have their place in development of the region. In socioeconomic terms, the high cost of improved pastures and the risk associated with development of land over which the farmer has no title currently limit any widespread acceptance of improved pasture technology in the short term. Before improved pastures could become economically feasible and socially acceptable, pressure on useful land must increase, as is currently being observed through increasing population and weed invasion of the Imperata cylindrica dominant pastures.

Economics

Gibson (1979) has compared the economic returns of two pasture improvement strategies and determined that a set stocked pasture developed by a farmer who already owns cattle would require an investment of US$165.31 per hectare which could be returned in two years. A pasture ley grazed by cattle in a cropping system was costed at US$361.33 per hectare for the first six years during which time the gross return from cattle sales and rice production was $500.98 per hectare. If similar figures are employed for an improved pasture supplementary feeding system, a cost of US$96.56 per hectare for seed and initial fertilizer application plus US$28.32 labour would yield a gross return over one year of US$395.96 per hectare of improved pasture from the additional liveweight gain without consideration of any increase in reproductive rate. Utilization of improved pasture as a supplement to native range is obviously superior and has the additional advantage over conventional improved pastures and pasture leys that it could be integrated into the existing system more easily and requires lower management and financial inputs.

The economic advantage accruing to the provision of a sodium supplement would, however, be higher again. Salt, delivered to highland centres would cost approximately US$0.40 per head if fed year-round to provide a return similar to that calculated above for the use of supplementary cut improved pasture (US$7.00 per head per year). If urea is included in the supplement year-round (although there is little indication that it is beneficial in the highland situation) at 20 g per day the cost per head per year would rise by approximately US$2.70. It has not been determined whether a combination supplement of improved pasture and salt may provide a greater advantage; however, it is suggested that the most economic alternative on the basis of return to investment would exclude the improved pasture supplement.

Other improvements that would assist in removing factors limiting the productivity of cattle in the region include the construction of cattle yards to facilitate handling for vaccination against foot-and-mouth disease and haemorraghic septicemia and to reduce the risk of theft and predator attack. Such simple improvements which were shown by the survey to be uncommon, could be coupled with nutritional improvements of supplementary salt and forage. The combination of these two strategies would lead to an immediate increase in the development of the cattle industry in the highlands.

Constraints to the productivity of cattle in the highlands may not all be soluble; consider that of topography. The difficult nature of the terrain is one factor favouring the continued raising of cattle because few agricultural crops can be grown competitively in the region. However, the restricted grazing times of cattle in the highlands which is necessitated by the terrain, theft and predators also limits feed intake leading to cattle consuming a submaint-enance diet for some periods of the year. Sodium and forage supplements would increase productivity but the digestibility of forage produced in the region may not be high enough throughout the year to allow intakes sufficient to provide liveweight maintenance, particularly when the additional energy requirements of walking in steep terrain are considered. Nevertheless, the alternatives to cattle production in many areas of the highlands are far more limited than they are for lowland Thailand thus making local comparative economics attractive when opium production is excluded.

Future Scenario

The alternative strategies to improve the nutrition of cattle in the highlands each have their place in future development. In the near future, improved pastures will most probably remain socially unacceptable because of the large inputs of capital and labour that they require. However, the provision of a salt (sodium chloride) supplement would be more acceptable and provide higher returns to capital in the short term. The grazing pressure on native *Imperata cylindrica* dominant (native) pastures may then increase thereby accelerating the rate of weed invasion which could effectively reduce the available grazing area. This continuing increase in

grazing pressure coupled with increasing competition for land as the human and cattle population of the highlands rises could then create a need for improved pasture development. Initially, improved pastures may be used to provide cut forage as a supplement to native pasture to increase feed intake. As the availability of native pasture decreases further, the only alternative will be the establishment of large areas of improved pastures to be intensively managed. The social acceptability of this system would be expected to be higher by that time because alternative means of raising cattle involving lower capital and labour inputs will be few.

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บทสรุป

หนังสือนี้เสนอเรื่องราวเกี่ยวกับปศุสัตว์โค-กระบือและแกะในพื้นที่ที่สูงซึ่งมีความจำเป็นจะต้องพิจารณาถึงส่วนประกอบต่างๆที่จะเป็นขีดจำกัดต่อการพัฒนาอุตสาหกรรม และการที่จะพัฒนาแผนการเพื่อทำการปรับปรุงการผลิตปศุสัตว์และการพัฒนาอุตสาหกรรมเกี่ยวกับปศุสัตว์ การวิจัยที่เกี่ยวกับเรื่องนี้โดยตรงได้กล่าวไว้ในเอกสารนี้แล้ว และความต้องการสำหรับการพัฒนาด้านการเกษตรในเขตนี้จึงได้จัดให้มีการกระตุ้นเพื่อทำการศึกษาเกี่ยวกับเรื่องต่อไปนี้

ในการสำรวจพื้นที่อันกว้างใหญ่ที่อยู่ในที่สูงได้ชี้ให้เห็นว่าการผลิตปศุสัตว์จำพวกโค-กระบือ ยังอยู่ในระดับต่ำในทุกกรณี และระดับต่ำดังกล่าวนี้ก็จะเป็นด้านการจัดการด้านวิชาการหรือเทคนิค และด้านเศรษฐกิจในการลงทุนซึ่งเป็นเรื่องธรรมดาสำหรับอุตสาหกรรม พวกเจ้าของปศุสัตว์ไม่ได้สนใจที่จะเพิ่มระดับในด้านต่างๆเหล่านี้เพราะว่าพวกโค-กระบือไม่ได้รับการเลี้ยงดูในแบบของธุรกิจ ความแตกต่างหลายๆอย่างในลักษณะการเป็นเจ้าของสัตว์ และทัศนคติต่างๆที่มีต่อพันธุ์สัตว์ระหว่างกลุ่มชนที่มีประเพณีวัฒนธรรมแตกต่างกันออกไปก็ได้มีส่วนสัมพันธ์ต่อจุดมุ่งหมายสำหรับการที่จะเลือกเก็บเอาโค-กระบือชนิดใดหรือตัวไหนเพื่อเลี้ยงไว้รวมทั้งการที่พวกเขานำไปใช้ในการบูชายัญในพิธีทางศาสนา การผลิตจึงได้ตกต่ำลงไปในทุกกรณี ข้อที่ควรจะระมัดระวังที่สำคัญๆในการพัฒนาอุตสาหกรรมที่ได้เสนอแนะจากการสำรวจคือ เรื่องโรค โจรภัย สัตว์อื่นที่เป็นอันตรายต่อสัตว์เลี้ยง และการให้อาหาร การลงทุนทางด้านเทคนิค และการจัดการเพื่อแก้ไขปัญหาแรกทั้งสามอย่างก็คงจะพอทำได้ แต่ไม่ได้นำเอามาปฏิบัติกันเพราะว่าขาดความรู้ในบางกรณี และเพราะว่าการเลี้ยงและผลิตสัตว์แต่ละชนิดนั้นได้รับการพิจารณากระทำกันโดยพวกชาวเขาเผ่าต่างๆ ซึ่งก็จะอยู่ในระดับที่ต่ำมาก ในการที่จะประกันการลงทุนเช่นนั้น

ระดับของการผลิตปศุสัตว์ที่เลี้ยงตามสภาพแบบดั้งเดิมในพื้นที่ที่สูงก็จะให้ผลผลิตต่ำ และจะมีส่วนสัมพันธ์กับการให้อาหารไม่ดีหรือถูกต้องและการปรับตัวของสายพันธ์ปศุสัตว์พื้นเมืองต่อสภาพแวดล้อมที่เลวร้าย จากการศึกษาเกี่ยวกับคุณภาพของหญ้าพันธุ์พื้นเมืองที่มีอยู่ซึ่งปศุสัตว์พันธ์พื้นเมือง

กินและย่อยเป็นอาหารในบริเวณพื้นที่ที่สูง ได้ชี้ให้เห็นว่าการผลิตปศุสัตว์ไม่น่าจะมีขีดจำกัดโดยธาตุในโตรเจนหรือฟอสฟอรัสที่เป็นส่วนผสมในอาหารสัตว์ในระยะเวลาเกินกว่า 1/3 ของปี (ฤดูฝนและฤดูหนาว) การผลิตปศุสัตว์ที่อยู่ในระดับต่ำได้พบว่ามีส่วนสัมพันธ์กับสัตว์ที่มีสมรรถภาพในการย่อยอาหารต่ำ ปริมาณอาหารที่สัตว์กินมีอัตราต่ำ และอัตราที่ต่ำของธาตุโซเดียมซึ่งมีอยู่ในอาหารจำพวกพืชที่สัตว์กิน การแพรขยายของวัชพืชที่เป็นการทำลายหญ้าเลี้ยงสัตว์พันธุ์พื้นเมืองชื่อ Imperata cylindrica โดยวัชพืชชื่อ Eupatorium adenophorum ได้ทำให้ระดับประมาณของหญ้า Imperata ในพื้นที่ที่สูงลดลงต่ำกว่าระดับปกติของพื้นที่เขตอื่นๆ

การศึกษาเรื่องอาหารของปศุสัตว์เกี่ยวกับการให้อาหารเสริมทั้งที่เลี้ยงในแปลงหญ้าพันธุ์พื้นเมืองและแปลงหญ้าพันธุ์ปรับปรุง ในตอนแรกๆได้พบว่าปศุสัตว์ประเภทโค-กระบือพันธุ์พื้นเมืองในพื้นที่ที่สูงสามารถเพิ่มน้ำหนักสัตว์ขณะมีชีวิตอยู่ได้สูง (343 ถึง 535 กรัม ต่อตัวต่อวัน) เมื่อได้อาหารมากพอ การให้อาหารเสริมสำหรับปศุสัตว์ในฤดูแล้งโดยให้เล็มหญ้าพื้นเมืองพร้อมทั้งกากน้ำตาลยูเรียและแรธาตุต่างๆก็ได้เพิ่มน้ำหนักของสัตว์ขณะมีชีวิตอยู่ และได้เสนอว่ามีการตอบสนองทั้งทางด้านพลังงานและแรธาตุต่างๆหรือยูเรีย น้ำหนักของสัตว์ขณะมีชีวิตอยู่ถ้ายิ่งมีอัตราเพิ่มสูงขึ้นก็ยิ่งมีอัตราการขยายพันธุ์สูง และอัตราการตายที่ต่ำของลูกวัวได้มีการบันทึกกล่าวถึงสารประกอบของธาตุโซเดียมในการที่ให้อาหารเสริมจำพวกโซเดียมไดไฮโดรเจนออร์โทฟอสเฟต (Sodium dihydrogen orthophosphate) การให้อาหารเสริมด้วยยูเรียโซเดียมฟอสฟอรัสและกำมะถันในฤดูแล้งและฤดูฝน และการให้อาหารเสริมโดยการตัดหญ้าพันธุ์ปรับปรุงให้กินก็ให้ผลตอบสนองเช่นเดียวกันในการเพิ่มน้ำหนักแก่สัตว์ที่ยังมีชีวิตอยู่ (เพิ่มขึ้น 30 ถึง 32% เกินกว่าที่ไม่มีการให้อาหารเสริม) ซึ่งมีผลเนื่องมาจากโซเดียมและอาหารที่สัตว์กินเพิ่มเข้าไปแต่ไม่ใช่ผลจากยูเรีย

ปศุสัตว์ประเภทโค-กระบือ ที่กินหญ้าในแปลงปรับปรุงพันธุ์ตามอัตรา 1.0 ตัวต่อเฮคแตร์มีน้ำหนักเพิ่มขึ้นเร็วเกินกว่าสามเท่าตัวของน้ำหนักที่เพิ่มในสัตว์ที่กินหญ้าในแปลงหญ้าพันธุ์พื้นเมืองตามอัตรา 0.06 ตัวต่อเฮคแตร์ ไม่ได้มีการบันทึกเกี่ยวกับการตอบสนองต่ออาหารเสริมจำพวกแรธาตุของสัตว์ที่ได้เลี้ยงในแปลงหญ้าพันธุ์ปรับปรุง เกี่ยวกับน้ำหนักของสัตว์ที่เลี้ยงในแปลงหญ้าตามอัตรา

น้ำหนักตัวของสัตว์ 210 ก.ก. ต่อเฮคแตร์ สามารถชี้ให้เห็นแนวทางที่จะเป็นไปได้สำหรับแปลงหญ้าพันธุ์ปรับปรุงว่าขณะที่สัตว์มีน้ำหนักตัวในแปลงหญ้าตามอัตราถึง 420 ก.ก. ต่อเฮคตาร์แล้ว จะนำไปสู่ทางที่จะทำให้แปลงหญ้ามีคุณภาพลดลง การควบคุมป้องกันพยาธิในลำไส้ของสัตว์ก็จะทำให้สัตว์มีน้ำหนักตัวเพิ่มขึ้น

จึงกล่าวสรุปได้ว่าข้อสำคัญเกี่ยวกับด้านวิชาการที่จะต้องมีการควบคุมในการพัฒนาอุตสาหกรรมปศุสัตว์บริเวณพื้นที่สูง คือควบคุมระบบการให้อาหารสัตว์ที่ยังแย่อยู่ซึ่งเป็นการจัดระบบแบบที่ได้เคยทำมาตั้งแต่ดั้งเดิม โดยเฉพาะมีการขาดธาตุโซเดียมและสัตว์กินอาหารไม่เพียงพอ ส่วนข้อสำคัญอื่นๆที่จะต้องระมัดระวังตามที่ได้ระบุไว้ในรายงานการสำรวจนั้นสามารถที่จะขจัดปัญหาได้โดยการผลิตปศุสัตว์ให้เพิ่มขึ้นจากการปรับปรุงด้านอาหารสัตว์ การผลิตแกะในพื้นที่สูงมักจะไม่ค่อยเติบโตหรือขยายในเชิงพาณิชย์ได้และไม่เป็นการประกันต่อการที่จะลงทุนเพื่อการพัฒนากันต่อไป